PROGRESS REPORT No. 1
BASE COURSES

FEBRUARY, 1956
No. 3

by
E. J. Yoder

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

PROGRESS REPORT NO. 1

PERFORMANCE OF RIGID PAVEMENTS CONSTRUCTED ON GRANULAR BASES

TO: K. B. Woods, Director
Joint Highway Research Project

February 1, 1956

File: 6-4-6
C-36-45F

FROM: Harold L. Michael, Assistant Director

Attached is Progress Report No. 1 on the Performance of Rigid Pavements Constructed on Granular Bases. This report has been prepared by Professor E. J. Yoder of the Project staff.

The report presents information which has been collected during a study of rigid pavements in Indiana, as well as some information collected on a study of airfield pavements. Other information obtained from a laboratory investigation and some additional field studies is also included.

Part of the information included in this report has been collected under another contract with the New England Division of the Corps of Engineers.

The report is presented to the Board as information.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Assistant Director
Joint Highway Research Project

HLM:cjg

Attachment

cc: J. R. Cooper
J. T. Hallett
F. F. Havey
G. A. Hawkins
G. A. Leonards
B. B. Lewis
R. E. Mills
B. H. Petty
Lloyd Poindexter
C. E. Vogelgesang
J. L. Waling

PROGRESS REPORT NO. 1

PERFORMANCE OF RIGID PAVEMENTS

CONSTRUCTED ON GRANULAR BASES

INTRODUCTION

The following will present several points of interest that have become apparent from a study of data obtained from performance of Indiana highways. Attached are groups of curves, and tables which summarize the data. It should be kept in mind, that a complete analysis of the data has not been made; therefore, positive statements and conclusions are not warranted at the present time. However, several trends are apparent and appear worthy of mention. Each will be discussed in subsequent paragraphs. For this discussion the terms "blowing" and "pumping" will be used symonymously.

EFFECT OF PUMPING (BLOWING) OF BASES ON PAVEMENT PERFORMANCE

It is believed that blowing of base courses per se may or may not constitute a serious problem. This appears true even though the formation of blow holes is rather dramatic and has received increased attention in recent years. In fact, several pavements built on crushed stone bases which have resulted in serious edge blows are still in excellent shape after many years of service. On the otherhand, it is believed that the formation of restraint cracks, and transverse cracks, can and does constitute a problem. Data on hand indicate that formation of these cracks are either a direct result of blowing, or at least are caused by the same set of circumstances which cause the blowing.

Data obtained from field observation indicate that a good correlation exists between number of joints and cracks effected by blowing, and the formation of transverse and restraint cracks. In several cases, however, serious cracking has occurred where little or no blowing exists at the present time. Notable among these cases are stretches 7 and 8, on US 52 north of Lafayette. These pavements did, however, pump very extensively up until recent years suggesting that blowing may stop after a period of time. Table 1 shows a summary of the performance data.

The effects of blowing on pavement performance will be discussed in more detail in later paragraphs.

Processes of "Blowing"

As defined by Vogelgesang (1) blowing results from water existing immediately under the pavement being forced from under the pavement at extremely high velocities which in turn erodes the base material. He classified this action as first and second stage. First stage blowing was evidenced by the formation of "blow holes" at the edge of the pavement, while second stage blowing was evidenced by accumulations of sand around the edge of the blow hole at the pavement edge.

Data obtained from this study have substantiated the above hypothesis. It has been reasoned, however, that a third stage of development exists. This third stage appears as restraint and transverse cracks in the pavement. Some doubt exists regarding the true mechanics of restraint crack formation. The data indicate very strongly that these cracks do constitute a third stage of development regardless of the various factors which cause them.

As mentioned previously, edge blow holes are generally an indication of pumping activity; however, it is believed that pumping action exists at the interior of the slabs as well as at the edge. This is indicated by the formation, in recent years, of restraint cracks at interiors of the traffic lanes, as well as in passing lanes.

The data on hand at the present time indicate that pumping of the subgrade soil up and through the base course is not a problem. However, the possibility that movement of sandy fractions, and fines of the base, up and through the base itself has been suggested whenever blowing occurs. Grain size distribution curves of base materials in service indicate a general distribution with depth of fine to course, with finer fractions occurring at the top of the base.

Figures 1 through 16, of the curves included in the summary present average gradations for the materials tested. These curves are averages of several tests made on base materials from each stretch of road surveyed and do not represent

[illegible] analysis these data have been organized according to [illegible] type of construction (trenched or [illegible]) and (3) length of [illegible] otherwise noted the slab length is 40 feet, and all joints [illegible] contraction joints.

Observation of Figure 1 through 9 indicate several significant [illegible]. First the lower half of the bases sampled, almost without exception, [illegible] less fines than the upper half. The exceptions can be found on the [illegible] graphs. Second, a layer of fine sandy material exists nearly always [illegible] of the base. The exact course of this latter material is not known at [illegible] but as will be brought out later, this layer appears to influence the pavement behavior as much as any other factor. It should be mentioned that data [illegible] from New Jersey pavements indicate the formation of a layer of similar nature under those pavements.

It has been reasoned that this layer can come from several probable sources. First, it may result from rolling the aggregate base during construction (2) it may have been placed on top of the base as a leveling course, (3) it may be cement from the slab, or (4) it may represent an accumulation of fines due to pumping action. The consistancy of its occurrence rules out the second possible cause listed above. Tests will be made to determine the chemical and minerolgical content to check on item No. 3 listed above. Regardless of the source of this material, its effect on blowing is at once apparent. Observation of figure 1 reveals that this material is primarily sand containing on the average 17 per cent by weight passing the No. 200 mesh sieve at joints showing no blows At joints showing the first stage of blowing (clear water) this material contains on the average of 28 per cent fines. This suggests that this high accumulation of fines results in an impervious layer immediately under the pavement which results in blowing. At joints showing second stage of development, this material contains only about 15 per cent fines suggesting that the material pumped out from under the pavement comes from this layer.

If the above is a correct hypothesis, it follows that the [illegible] enters the joint and forms restraint cracks comes from this [illegible] assumed that restraint cracks are formed by a bending action of [illegible] removal of this upper layer as support is still the cause.

It will be noted that in the more open graded bases, [illegible] this layer is either relatively clean or missing [illegible] curves consistently show more fines in the upper one half [illegible] lower half of the base, it is believed that movement of fines [illegible] and through the base material is at least one of the [illegible]

It should be mentioned, however, that since the [illegible] at non-pumping joints other factors certainly enter [illegible] Primary among these, would be cement from the slab during [illegible] formation of this layer due to rolling and final grading.

In addition, it will be noted in Figures 4, 5 [illegible] development of blow holes has not as yet caused a [illegible] included in these graphs. This is not surprising [illegible] pavements and it can be reasoned that pumping action has [illegible] a short period of time.

It has been definitely shown that a perched [illegible] the base and pavement is necessary for [illegible] that water is caused to move through the sub[illegible] The depth to water table has no apparent effect.

FACTORS AFFECTING BLOWING

Many factors influence the severity of the action known as pumping or blowing of bases. Among these are included the following:

1. Traffic
2. Base gradation and type
3. Depth and drainage of base
4. Climate
5. Grade and alignment
6. Structural capacity of the pavement

EFFECT OF TRAFFIC

Figure 17, with three overlays, shows the variation of performance with traffic. For these curves an estimate was made of the total number of repetitions of 18,000 pound axel loads during the life of the pavement. These data were calculated using the method proposed by Hveem (2). These data show that the occurrance of transverse and restraint cracks increases sharply beyond 16×10^5 repetitions of load. Also it will be noted that the pavements using gravel bases show greater tendency towards restraint crack formation than do those on sand and stone. The data indicate that the severest blowing occurs at about 20×10^5 repetitions and that it apparently is retarded at later stages. It can also be seen that blowing is active primarily on gravel bases. Stone bases have resulted in extensive first stage blowing but very little second stage. The orange overlay shows roughness data for each of the roads. It will be seen that sand and stone bases result in slightly higher roughness values for comparable traffic than do the gravel bases.

EFFECT OF BASE GRADATION AND TYPE

Bases which, according to this survey, result in the highest degree of distress are those constructed of gravel. It is believed that shape of the grain

[illegible] very [illegible]

It will be noted in Figures 1 through [illegible] that Fuller's maximum density curves are presented along with the actual average curves. Fuller's curve was calculated by means of the following formula:

$$\text{Per cent passing} = 100 \sqrt{\frac{d}{D}}$$

where d is the sieve size in question and D is the maximum size of aggregate. The severest pumpers are the gravels with poor gradation and which contain an excess of sand and fines. Stone bases which are relatively well graded have shown little or no pumping. Likewise well graded sand bases have shown only a slight amount of pumping. Some of the older gravel bases were constructed using well graded materials and have shown very little activity.

For a given gradation, the per cent of fines (passing a No. 200 mesh sieve) appears to affect the performance. The joints resulting in pumping have nearly always contained from three to four per cent more fines than those with no pumping. The quantity of fines, however, is a function of the grain size curve as well as type of material. This is illustrated when comparing the sands with the gravels where sands containing up to 14 per cent fines are showing satisfactory service. For comparable grain size curves, more fines can apparently be permitted in stone bases than those of gravel. This may be due to a higher coefficient of permeability of the stone bases. Further, grain shape certainly plays a part in this.

As a general statement it can be stated that gravel bases have shown poorest performance, with sand and crushed stone showing excellent performance. The data suggests also that poorly graded materials can be improved by proper blending.

EFFECT OF DEPTH AND DRAINAGE

Depth of base has no apparent effect insofar as blowing is concerned. This is true within the limited data available from this survey. This is further substantiated by data from New Jersey, Illinois and other states.

[illegible] relative to base thickness. [illegible] depth of base has no apparent effect for comparable traffic. However, these data are not conclusive and more attention should be directed towards determining the effect of depth

Drainage is most important and is tied in closely with permeability, (See Figures 18 and 19). Practically no blowing was found where shoulder drains were used, or where clean, well graded bases were used in through the shoulder construction. Bases constructed of stone through the shoulder have functioned very well. Gravel bases (poorly graded) constructed through the shoulder have shown serious distress regarding blowing and formation of cracks Shoulder drains constructed in these latter materials have shown little distress; however, some evidence exists that these too are becoming defective.

EFFECT OF GRADE AND ALIGNMENT

Elevated grades have no apparent effect on blowing or performance in general More blowing was found on fill sections than cut sections. However, this does not imply that the former sections are undesirable since the great amount of blowing of pavements on fills is due to the large mileage of road built on elevated grades. Low points on vertical curves appear to give the poorest performance but on the other hand some serious blowing was found at high points on vertical curves.

Insides of horizontal curves are by far the greatest offenders due probably to increased traffic at the pavement edge. Frequency of cracking is slightly greater in cuts than on fills (See Table 4)

EFFECT OF CLIMATE

Climate has a direct effect on blowing in that surface infiltration is blamed for the seriousness of the problem. Table 5 shows data obtained on US52, north of Lafayette at several different times of the year. It is seen that precipitation has a direct effect on severity of blowing. No apparent correlation exists between temperature and blowing. Type and gradation of the base material, and precipitation tend to obscure this.

Data [illegible] since some pavements have been [illegible] of 9" uniform highway pavements is generally [illegible] than the [illegible] pavements. Data from New Jersey indicate that some effect is shown when 10" uniform pavement with [illegible] dowel systems are used. This particular point deserves more attention.

It should be mentioned that some of the war time pavements which were constructed using 20-foot joint interval and no load transfer have shown good performance, except that considerable faulting has resulted. This is true of stretches 30 and 1. Stretch No. 30 has received very little heavy traffic while stretch one has received very heavy traffic. This latter stretch has shown considerable pumping in previous surveys, but it is significant that little or no restraint cracking has developed.

ACTION OF BASES AS A FILTER

The data show conclusively that granular bases are effective in stopping pumping of subgrade soils. The present criteria in use by the Corps of Engineers states that the base should be designed as a filter with the added requirement that the 85% size of the filter should be equal to or greater than 1/4 inch and that the filter should be non-frost susceptible. Since the vast majority of the pavements observed are constructed over cohesive soils the limiting 15% size of the filter is 0.1 mm.

Observation of the grain size curves reveals that all the base courses observed are functioning as a filter. The data suggest that the principal problem at hand is to devise criteria which will insure stability of the base proper rather than to prevent intrusion of fines from the subgrade.

It appears that the most fruitful approach to setting up design criteria for base courses under rigid pavements for pumping would be directed toward the shape of the grain size curve and particularly regarding the quantity of fines. It is significant that bases which are giving unsatisfactory service are either frost susceptible or are border line cases.

Correlation of Blowing with Cracking

Figure 20 in the appendix shows the relationship of blowing to performance as measured by number of cracks in the concrete pavement. The upper curves show data for restraint cracks while the lower are for transverse cracks occurring at the end 1/3 of the slabs. These data indicate that cracking is not necessarily associated with first stage blows, but that more cracks occur when blowing has progressed to the second stage. The numbers beside the curves represent the survey stretch numbers. Therefore, each line represents data for a particular highway, but for different sections on that highway. It is significant that the sections of a given highway showing greatest distress, on the basis of crack formation, also show greatest second stage blowing activity.

In Figure 21 is shown the distribution of restraint cracks across the pavement. It will be noted that the greatest number of cracks occur at about two feet from the outside edge.

Cited Referances

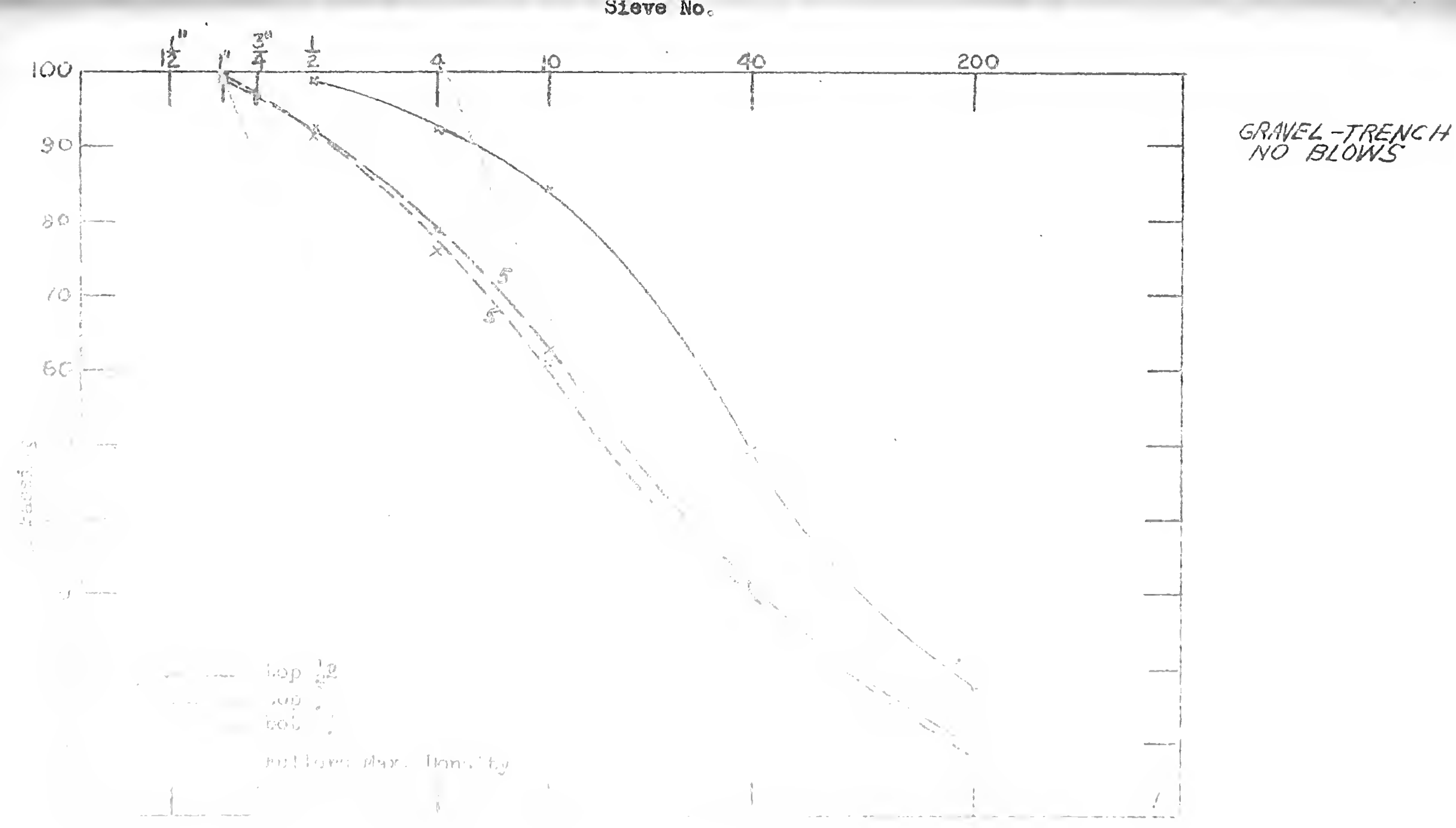
1. Vogelgesang C. E. "Effectiveness of Granular Bases for Preventing Pavement Pumping", Highway Research Board Bulletin 52, 1952

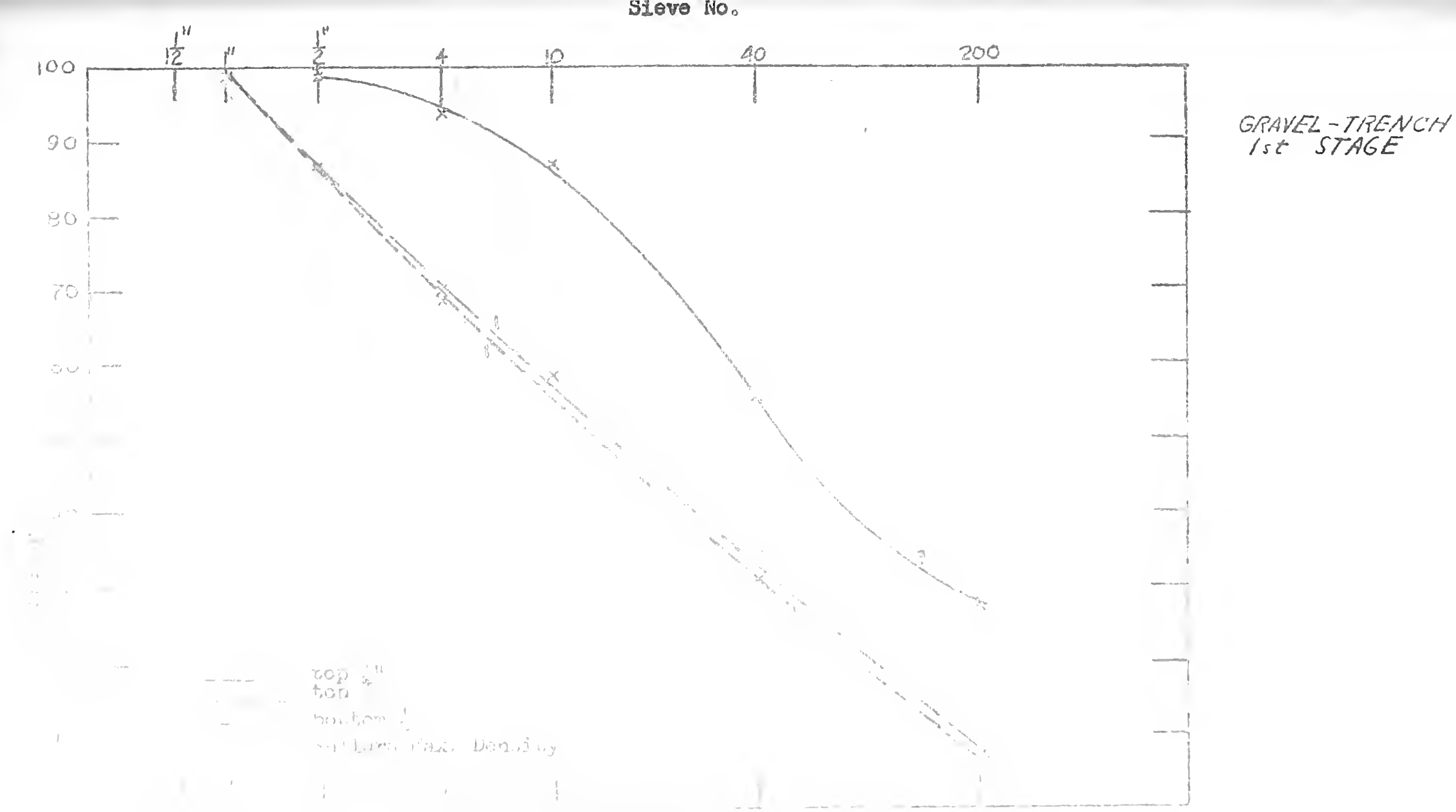
2. Horonjeff, Robert, and Jones J. H. "The Design of Flexible And Rigid Pavements" University of California Press, 1950

3. U. S. Corps of Engineers Engineering Manual, Part XII, Chapter 4, Nov. 1953

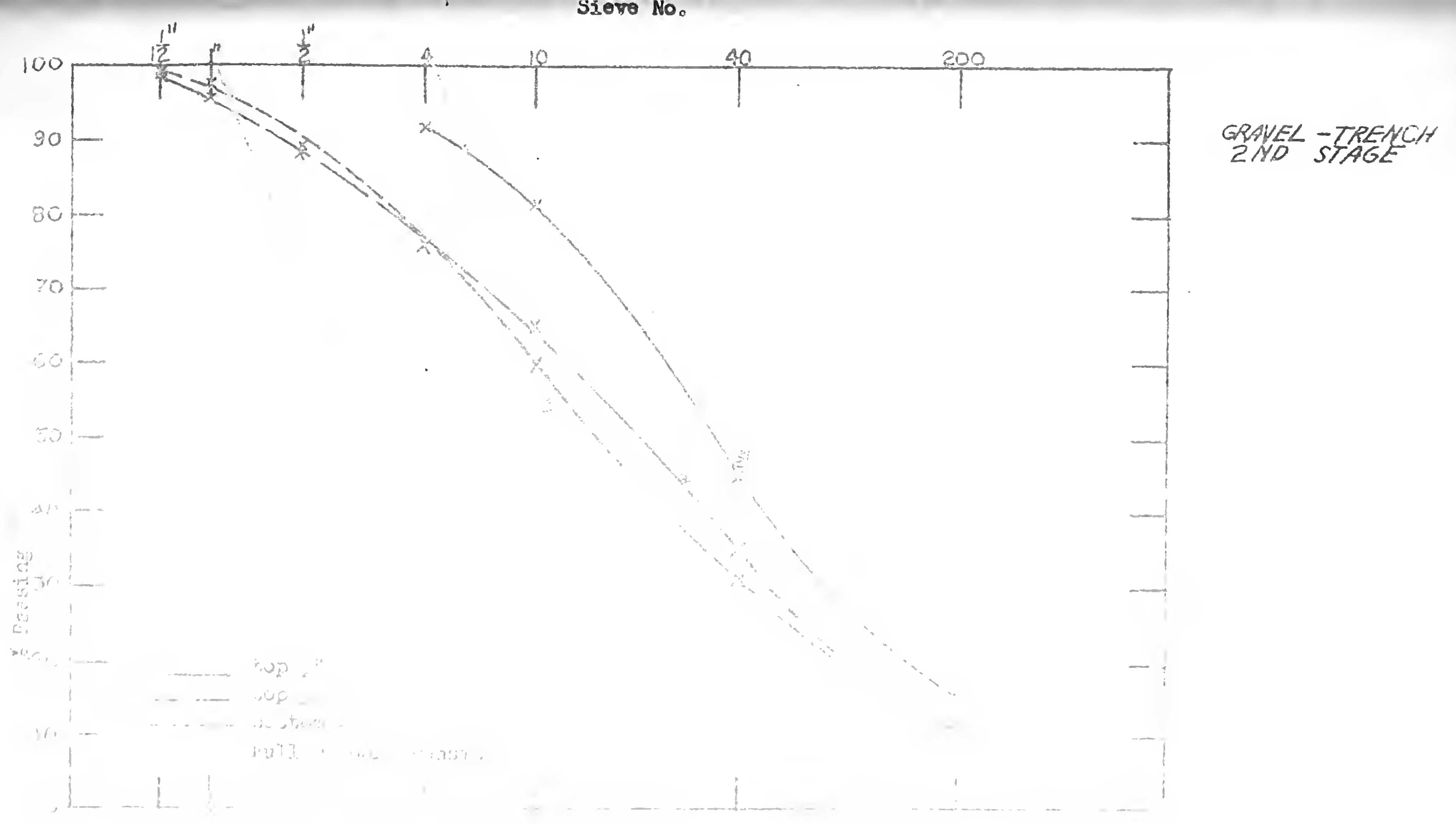
APPENDIX

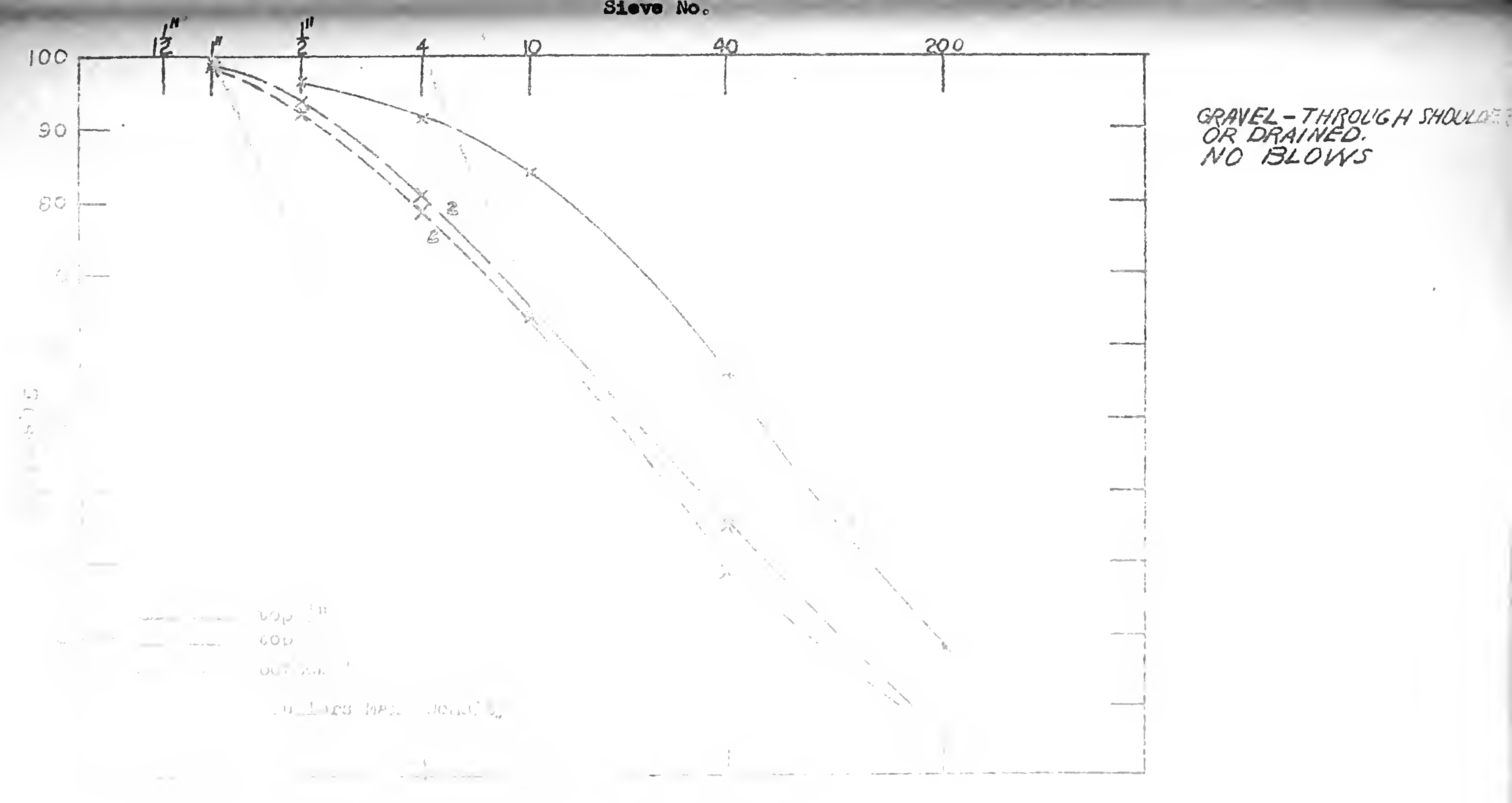
(Figures and Tables)

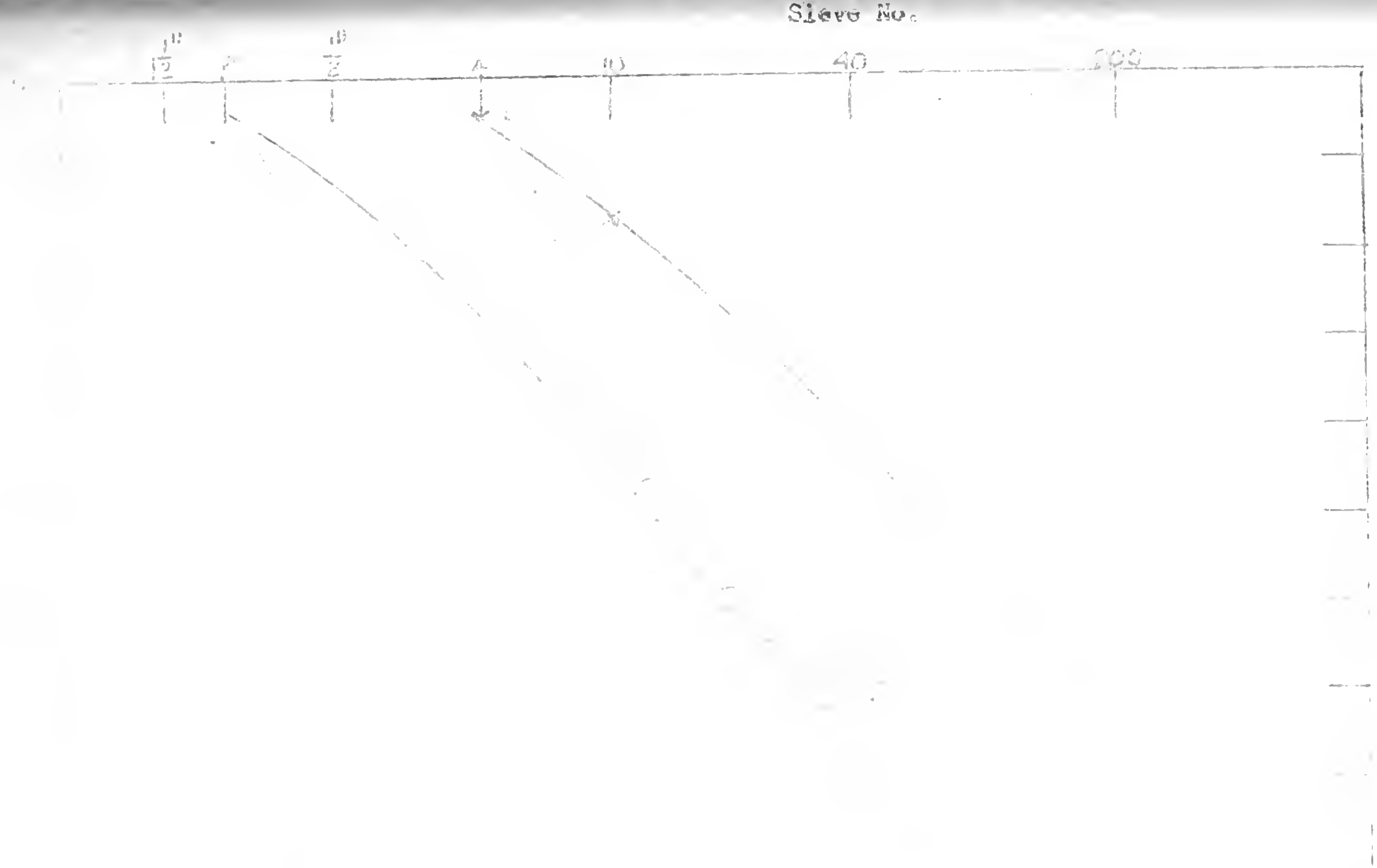

Sieve No.
1 1/2"
1"
3/4"
1/2
4
10
40
200
100
90
80
70
60
5
5
GRAVEL-TRENCH
NO BLOWS



Sieve No.
1½"
1"
½"
4
10
40
200
100
90
80
70
GRAVEL-TRENCH
1st STAGE

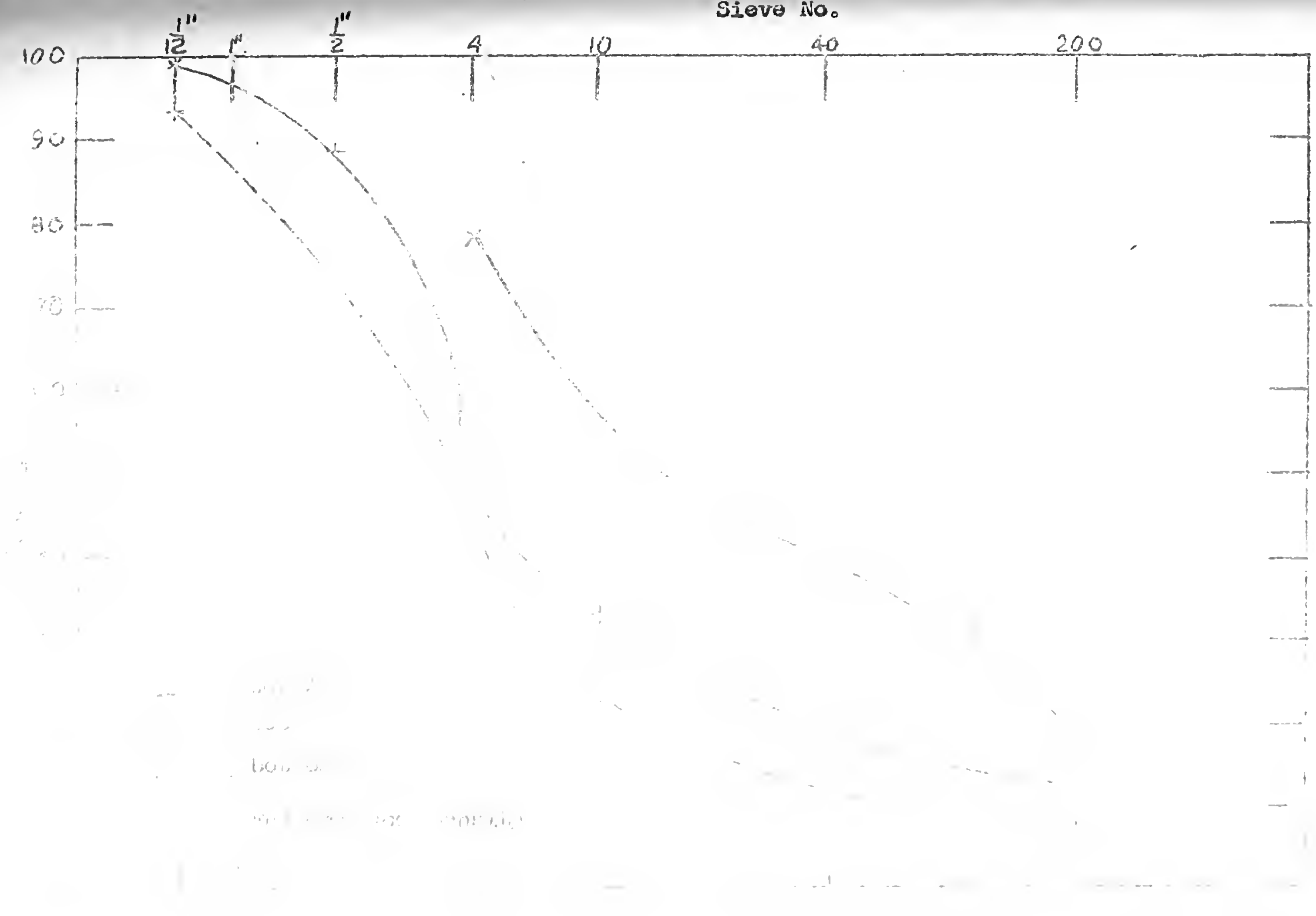

Sieve No.
1 1/2"
1"
1/2"
4
10
40
200
100
90
80
70
60
50
% Passing
GRAVEL -TRENCH
2ND STAGE


Sieve No.
1 1/2"
1"
1/2"
4
10
40
200
100
90
80
GRAVEL-THROUGH SHOULDER
OR DRAINED.
NO BLOWS

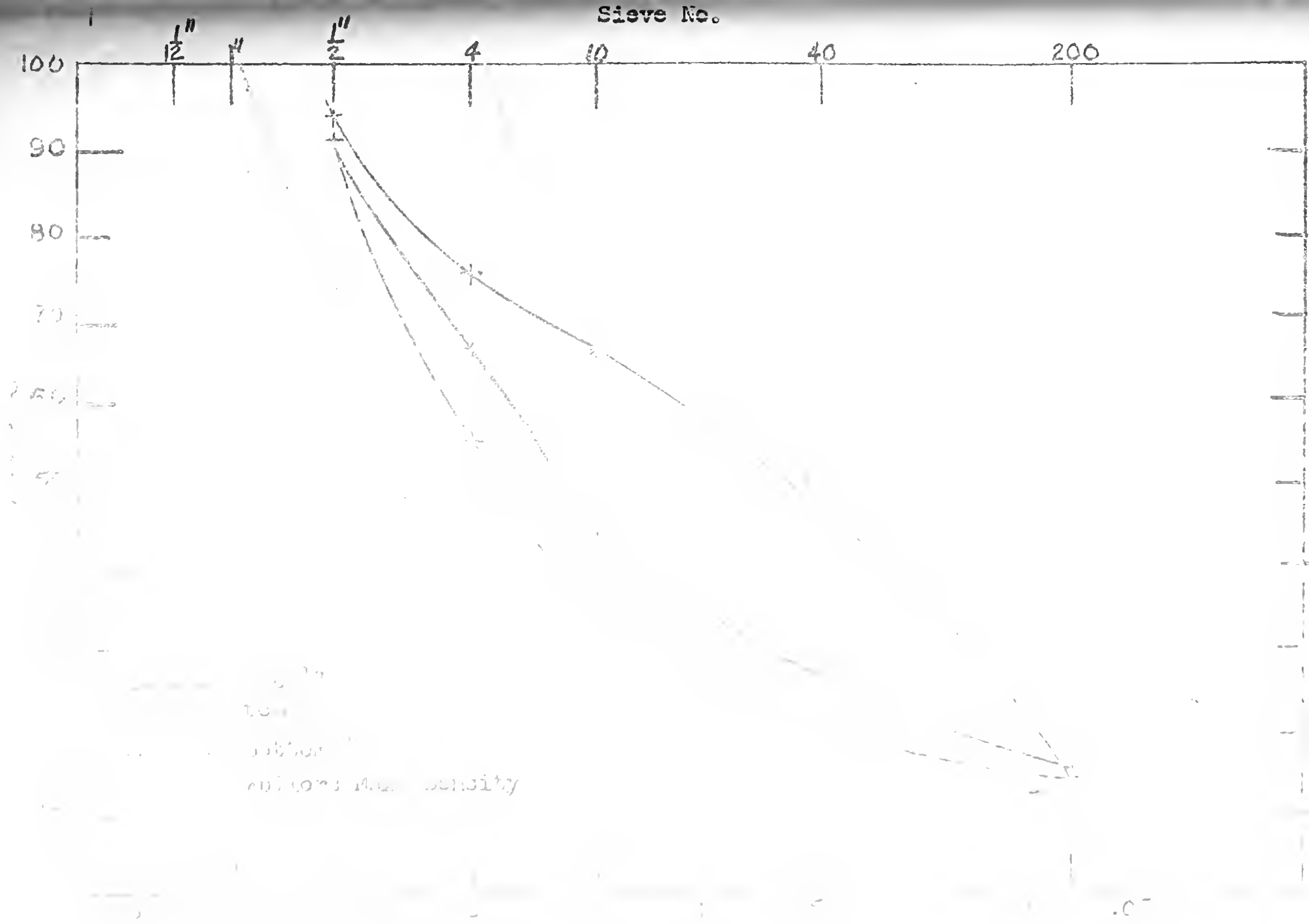


GRAVEL - THROUGH SHOULD[illegible]
OR DRAINED
1ST STAGE


Sieve No.
GRAVEL-THROUGH SHOUL
OR DRAINED
2nd STAGE

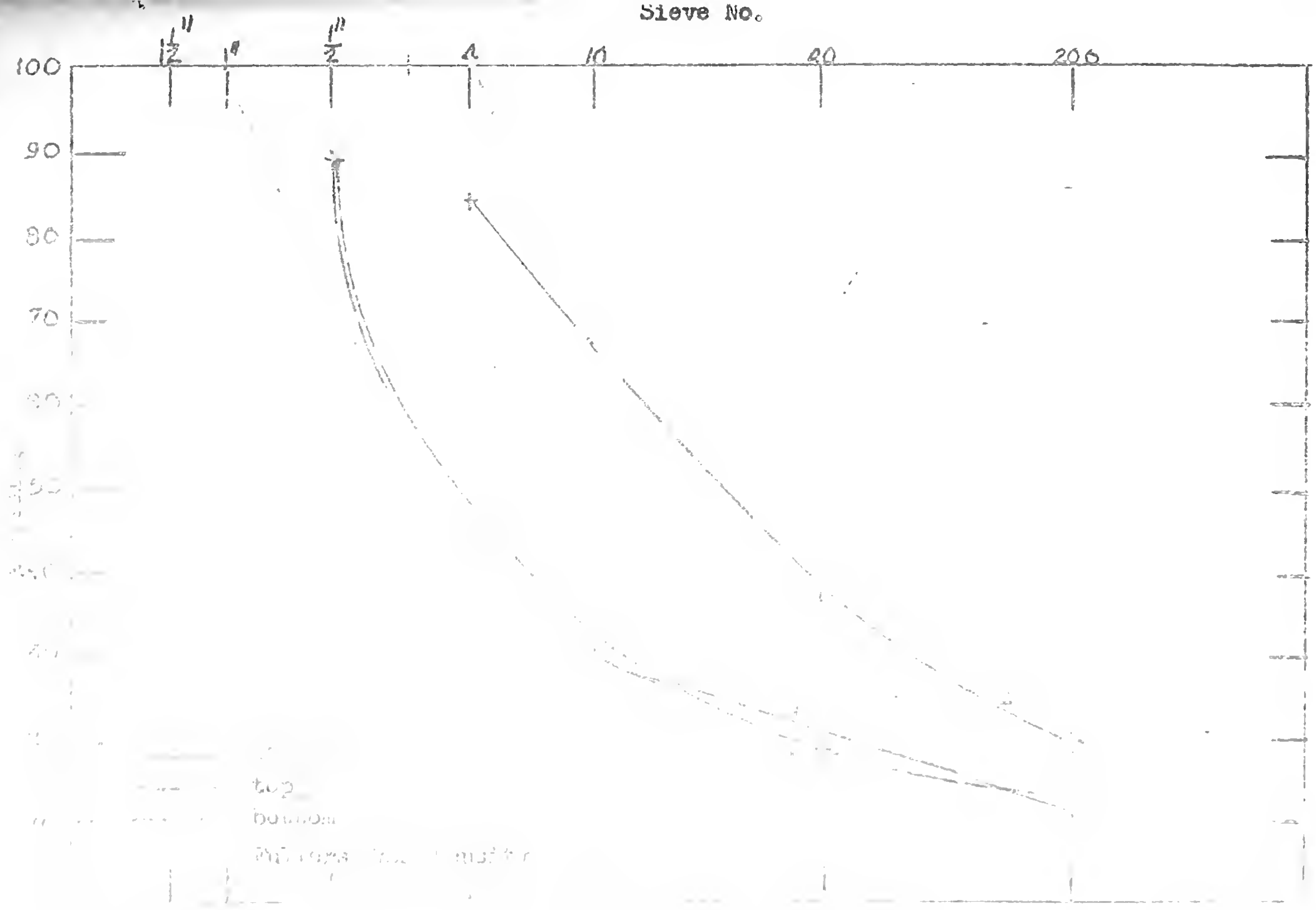


STONE INTRENCH
NO BLOWS



STONE IN TRENCH
1ST STAGE

STONE IN TRENCH
2ND STAGE



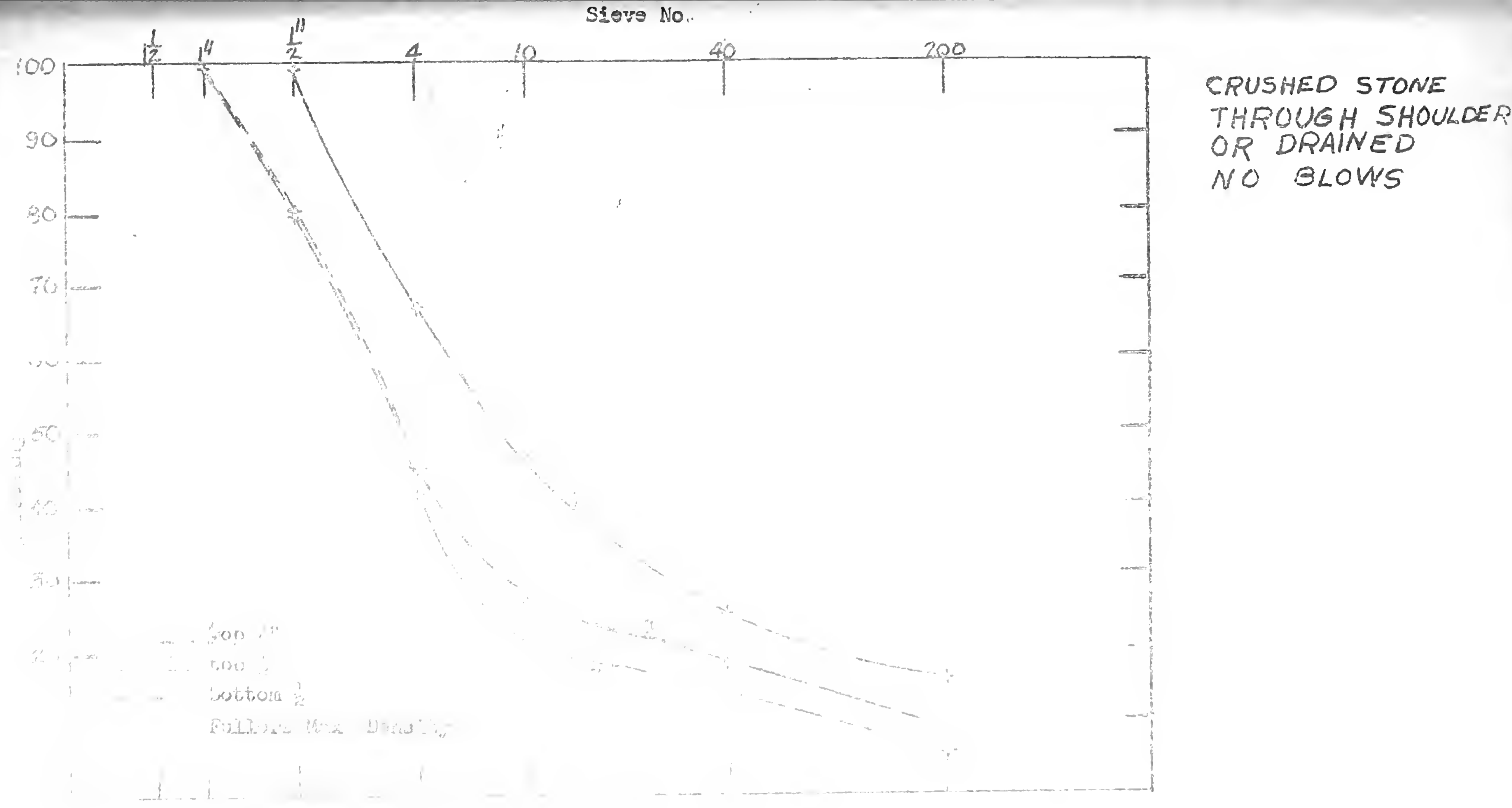
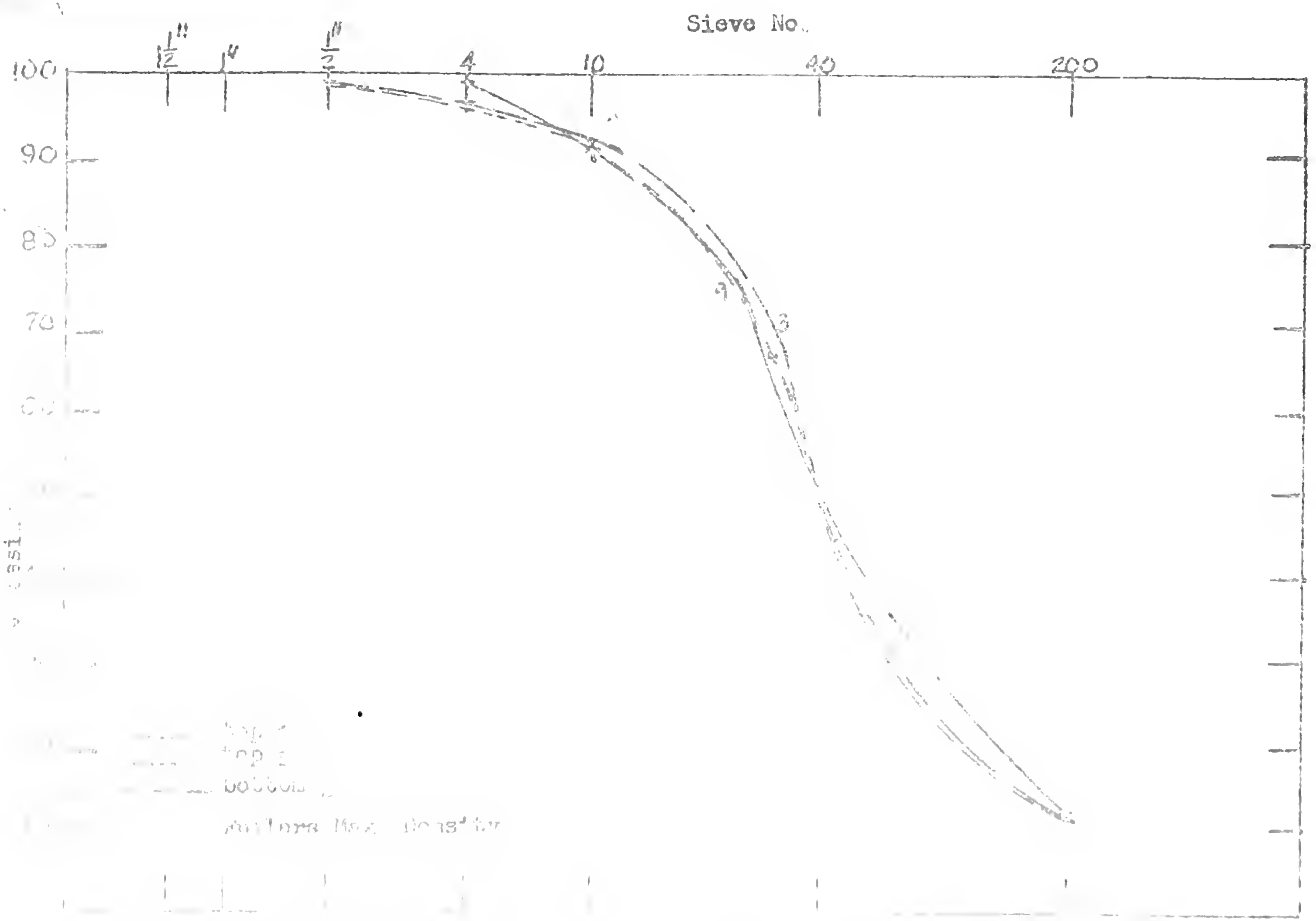
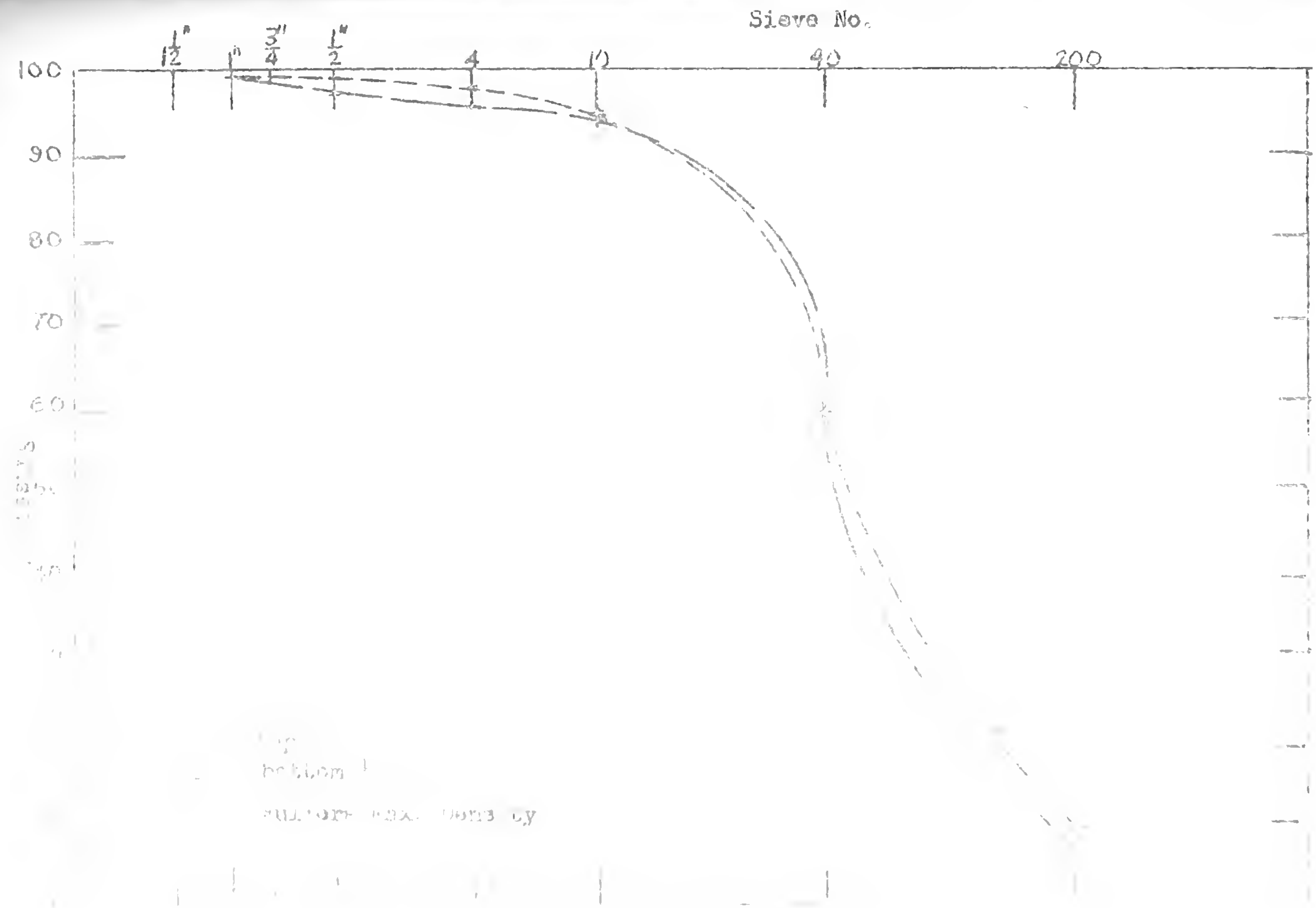

Sieve No.
1/2
1"
1/2"
4
10
40
200
100
90
80
70
50
40
Top ½
Bottom ½
Fullers Max Density
CRUSHED STONE
THROUGH SHOULDER
OR DRAINED
NO BLOWS

Fig. 10



SAND
NO BLOWS



SAND
1ST STAGE

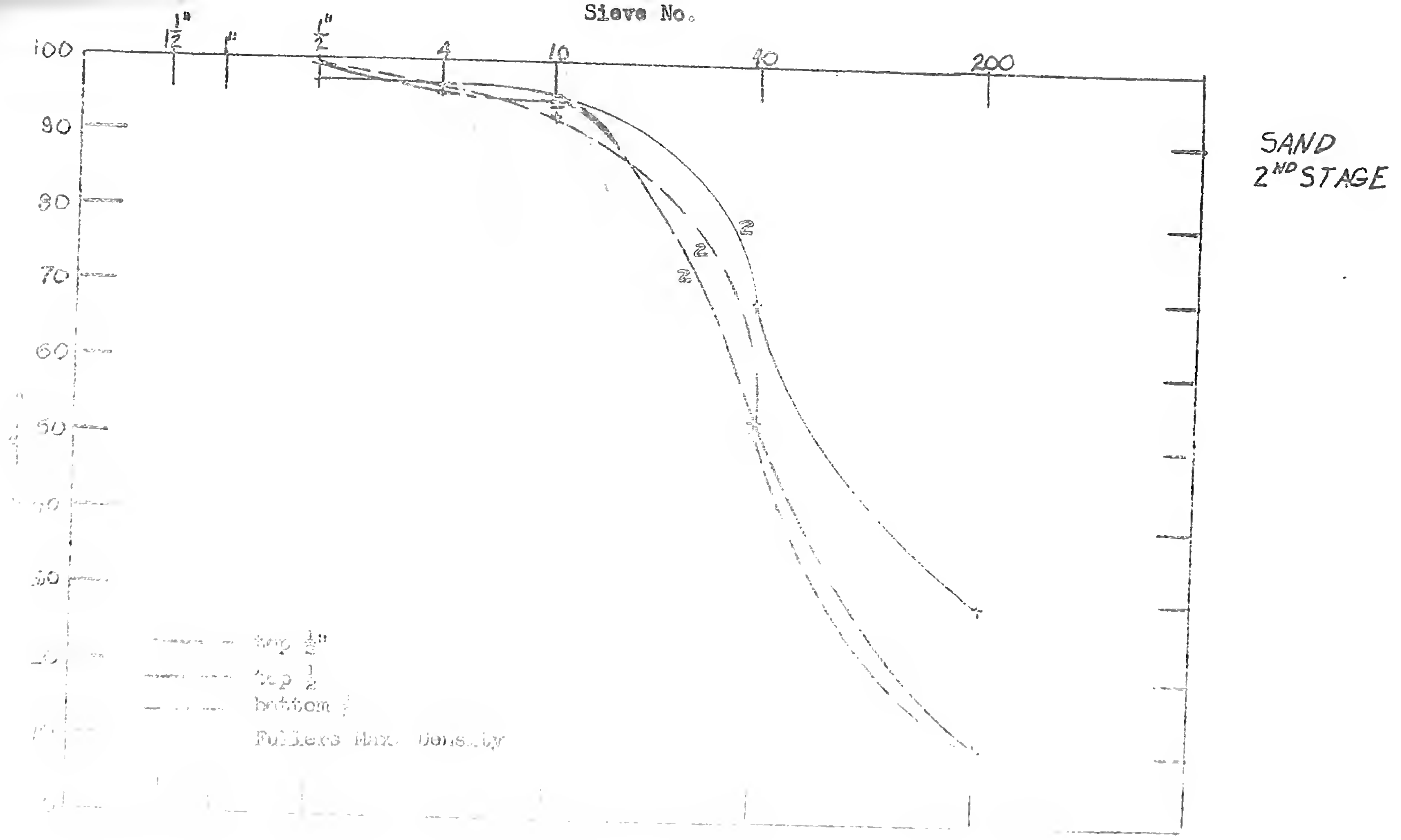
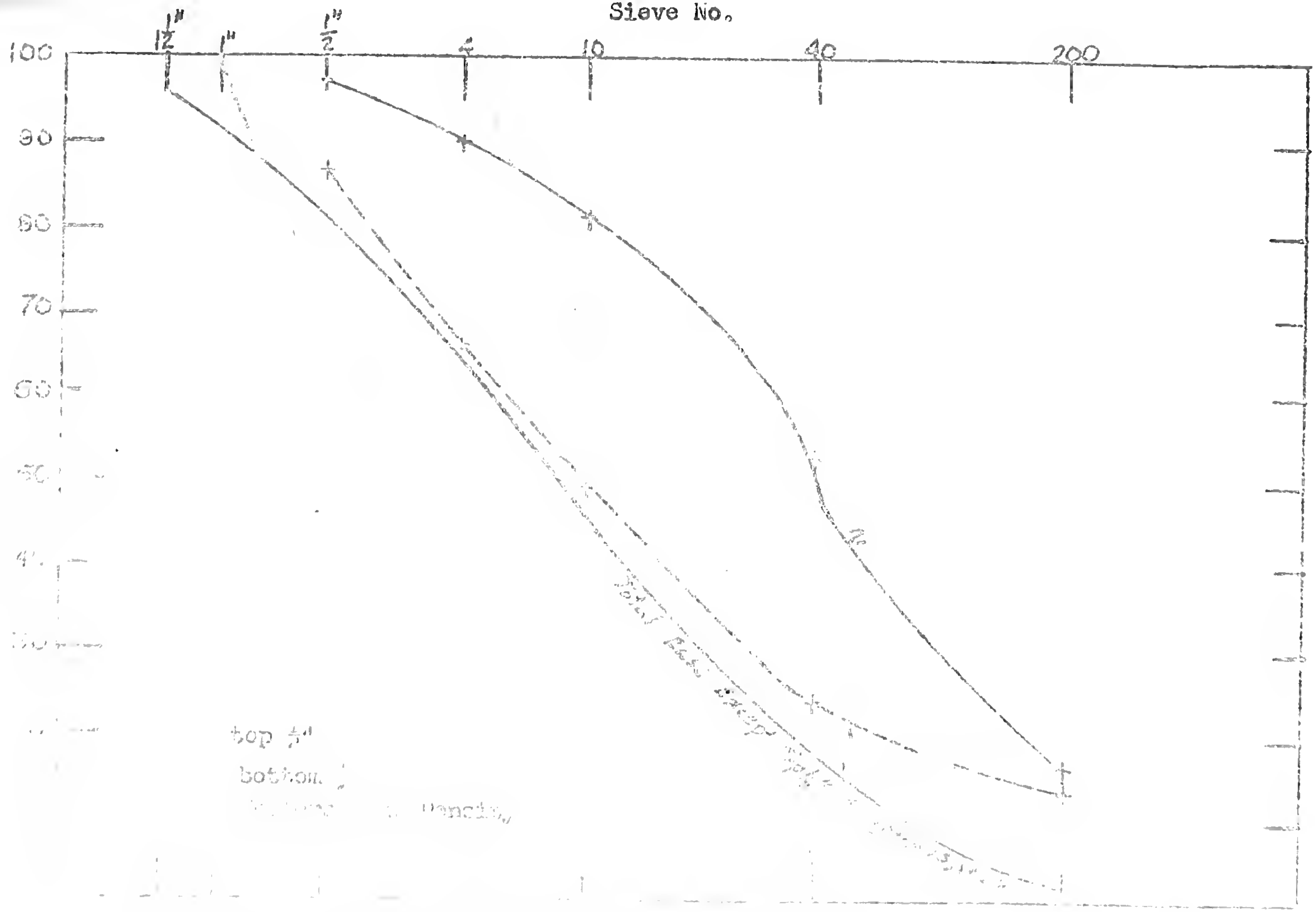
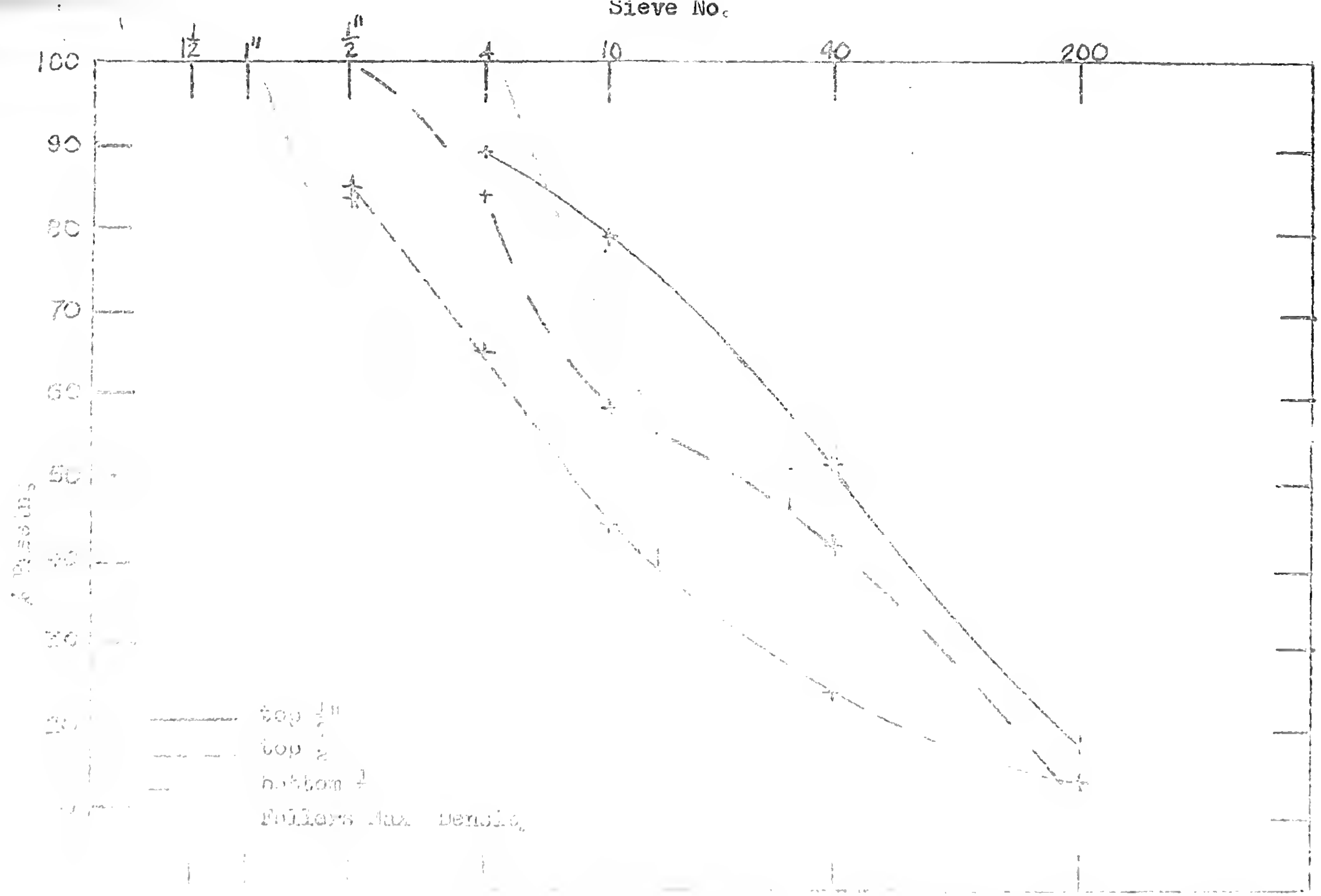

Sieve No.
100
90
80
70
60
50
30
1½"
1"
½"
4
10
40
200
SAND
2ND STAGE
Fullers Max. Density

Fig. 13

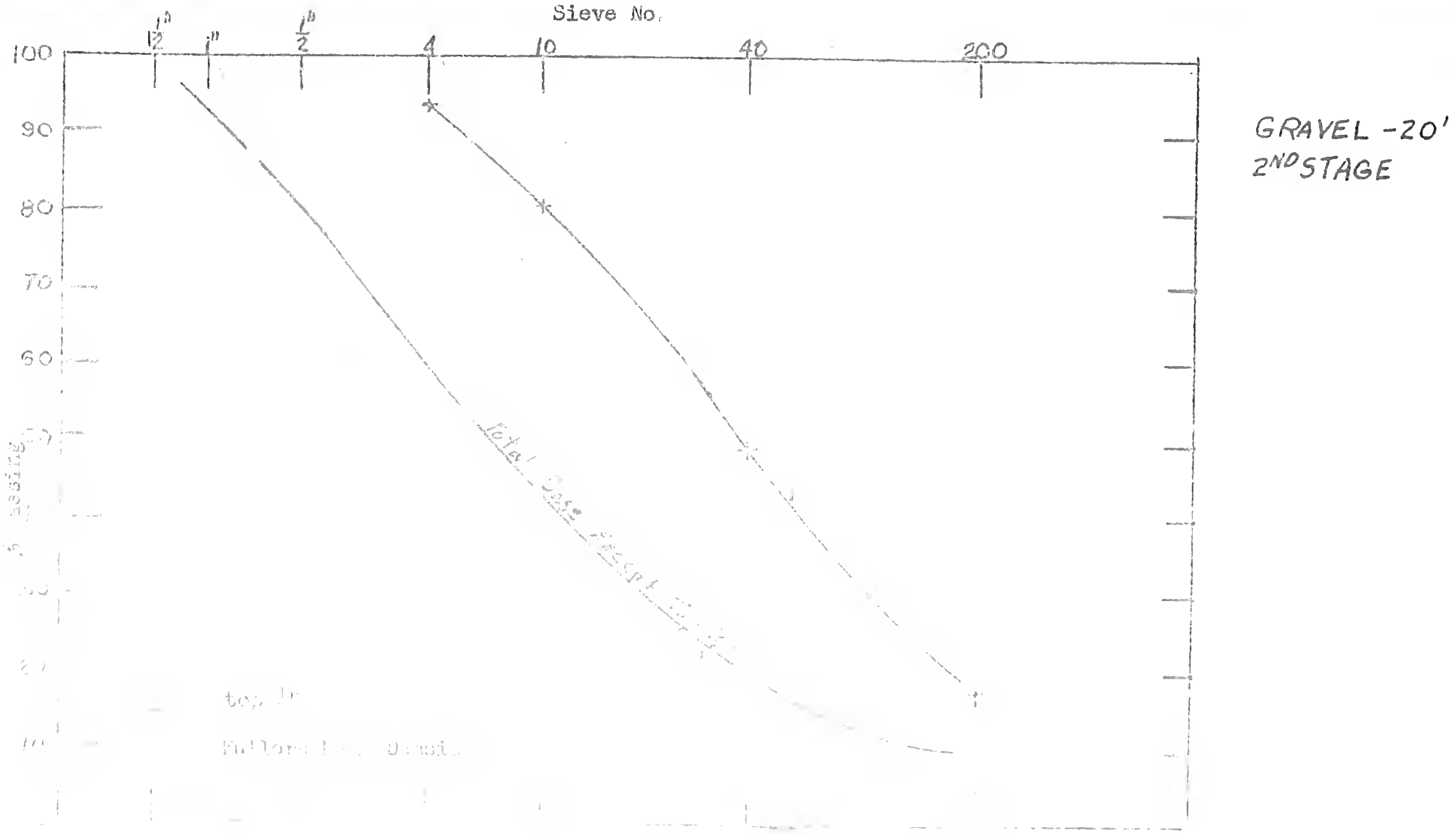
GRAVEL -20'
NO BLOWS



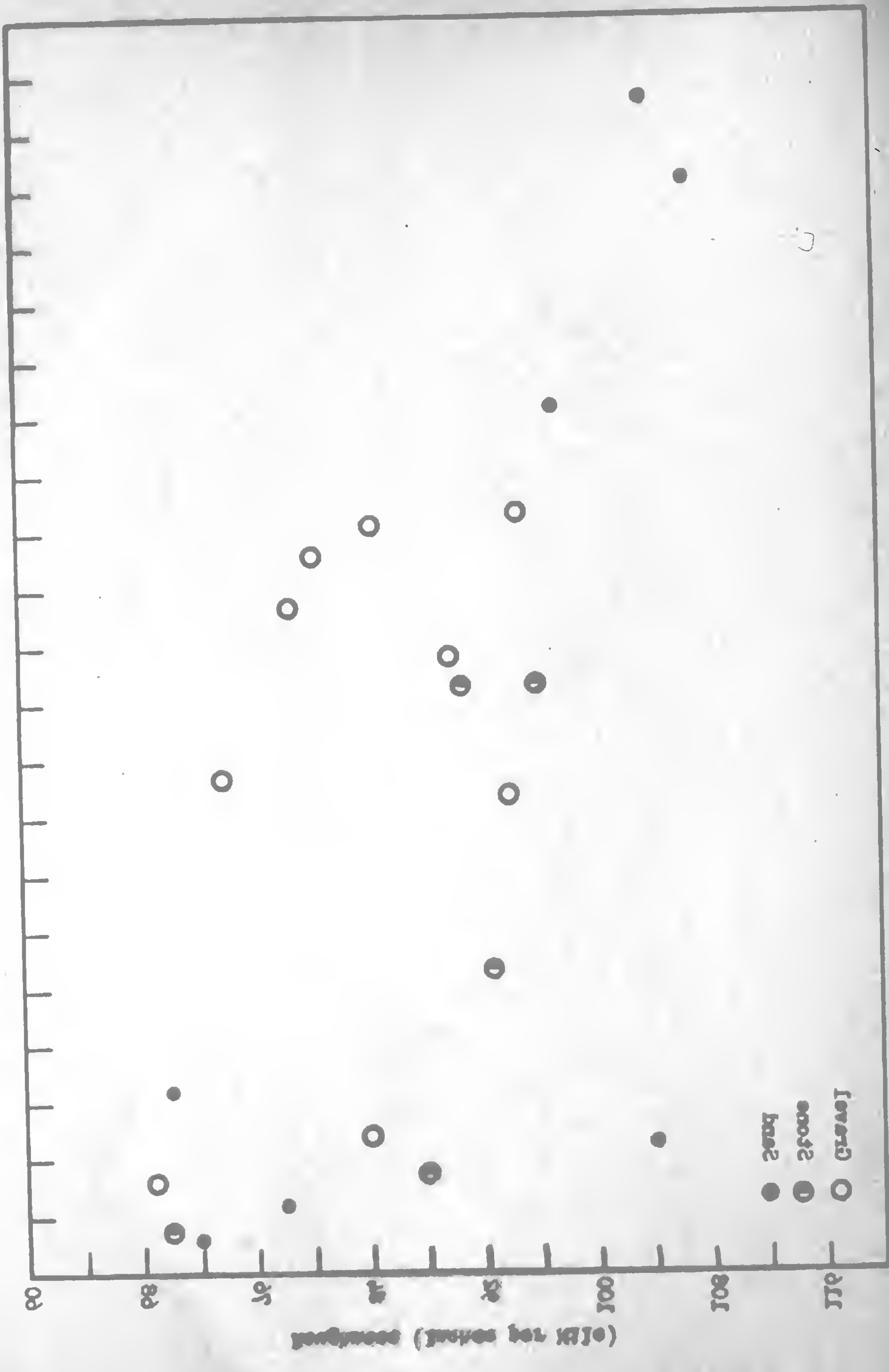


GRAVEL - 20'
1ST STAGE

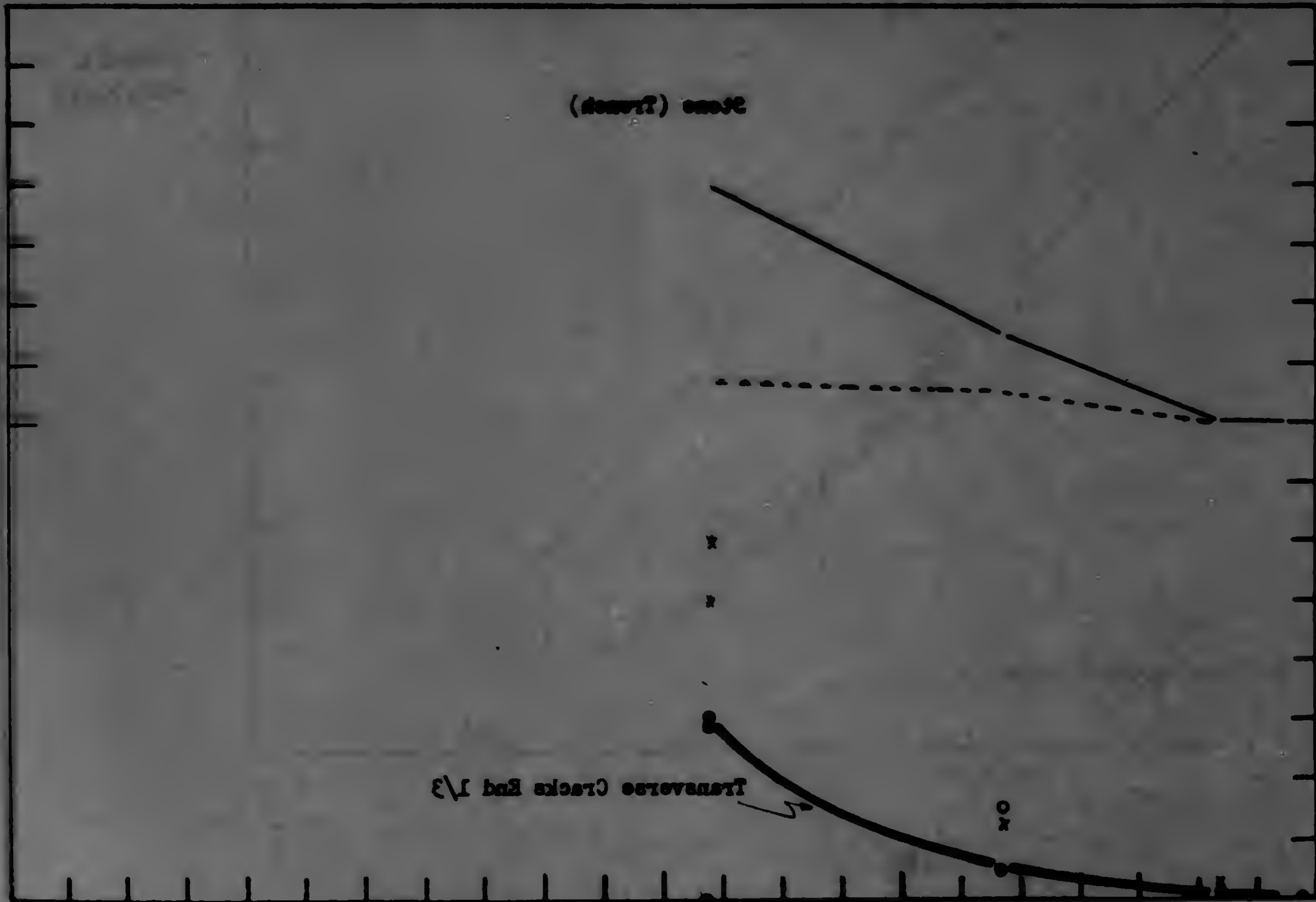
Fig. 16



Sieve No.
1½"
1"
½"
4
10
40
200
100
90
80
70
60
GRAVEL -20'
2ND STAGE


Roughness (Inches per Mile)
Sand
Stone
Gravel

[illegible] of Loads on Number of Crowns (Crown[illegible], Trench Construction, Traffic Lanes)


Stone (Trench)
Transverse Cracks End 1/3

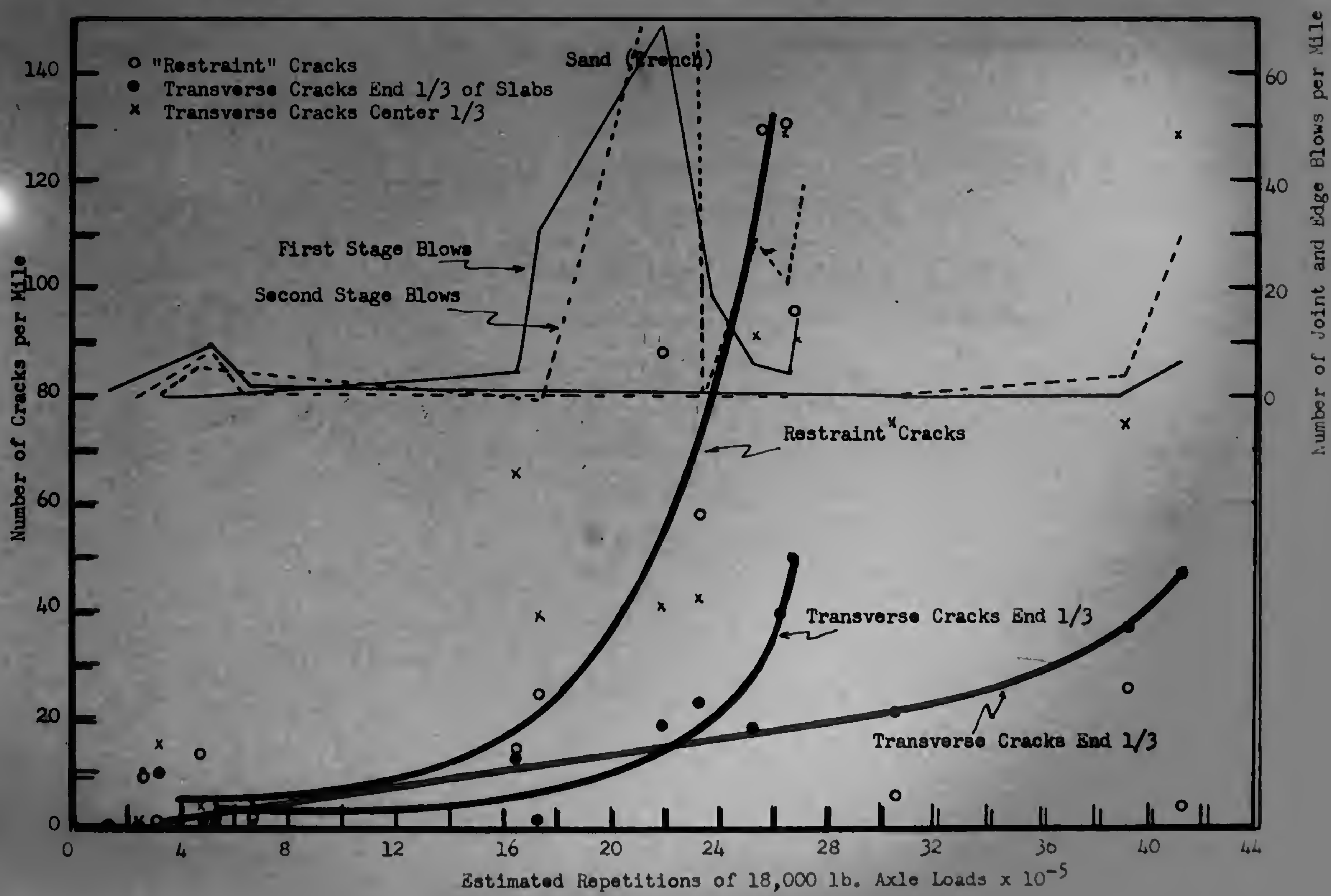


Fig. 17 Effect Of Repetition Of Loads On Number Of Cracks (Gravel, Trench Construction, Traffic Lanes)

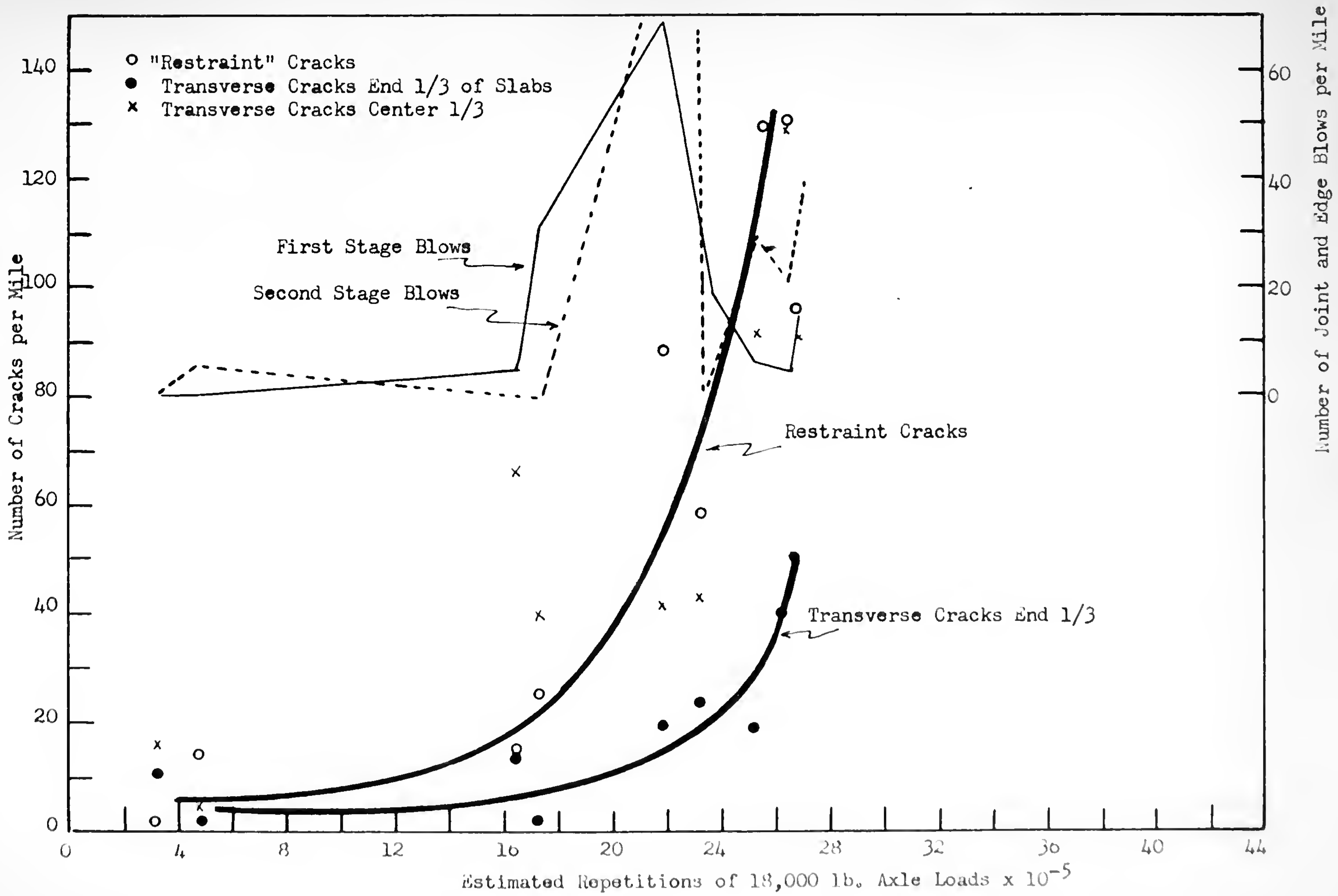


Fig. 17 Effect Of Repetition Of Loads On Number Of Cracks (Gravel, Trench Construction, Traffic Lanes)

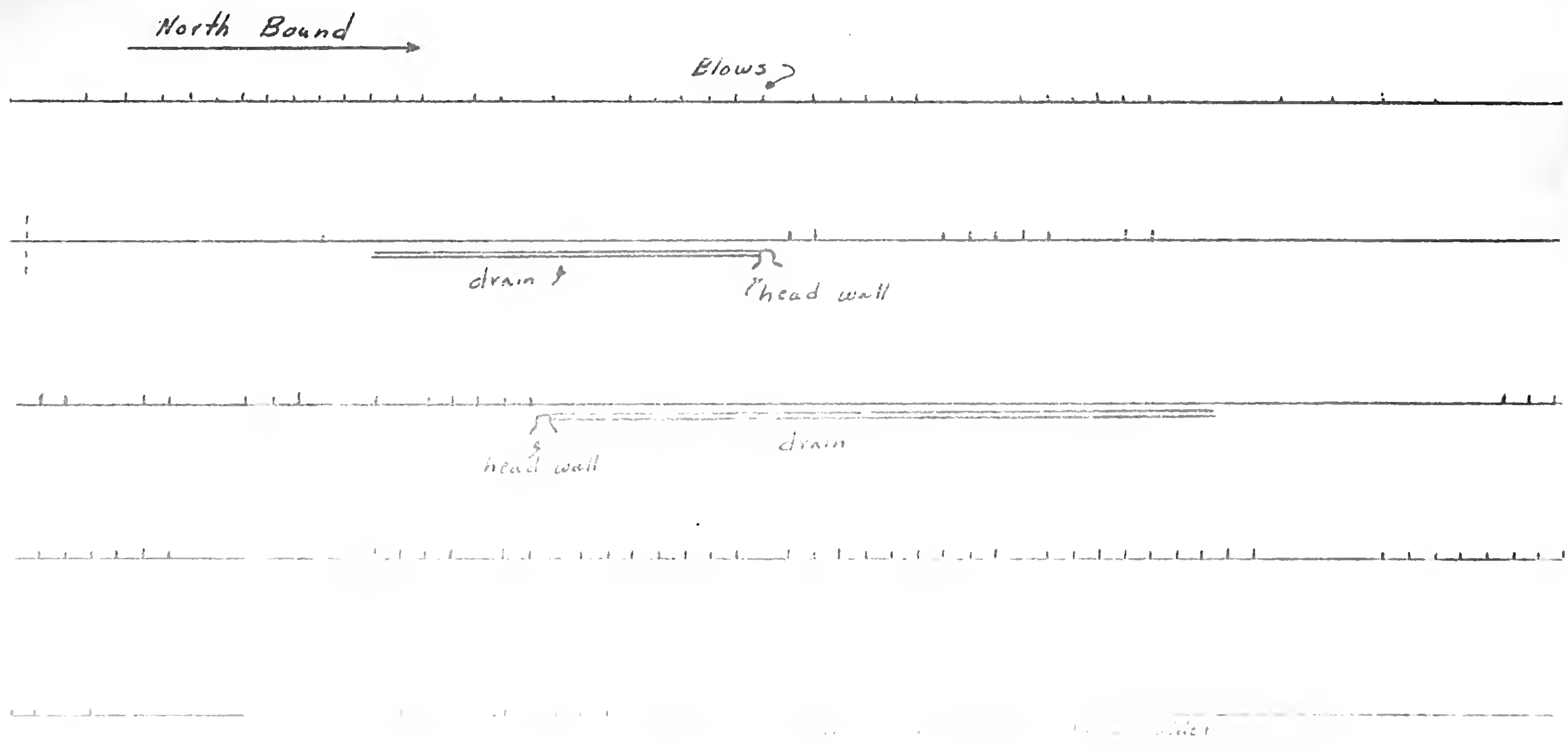


Fig. 18 Effect of Tile Drains, U.S. 52 (Base Through Shoulder Except as Noted)

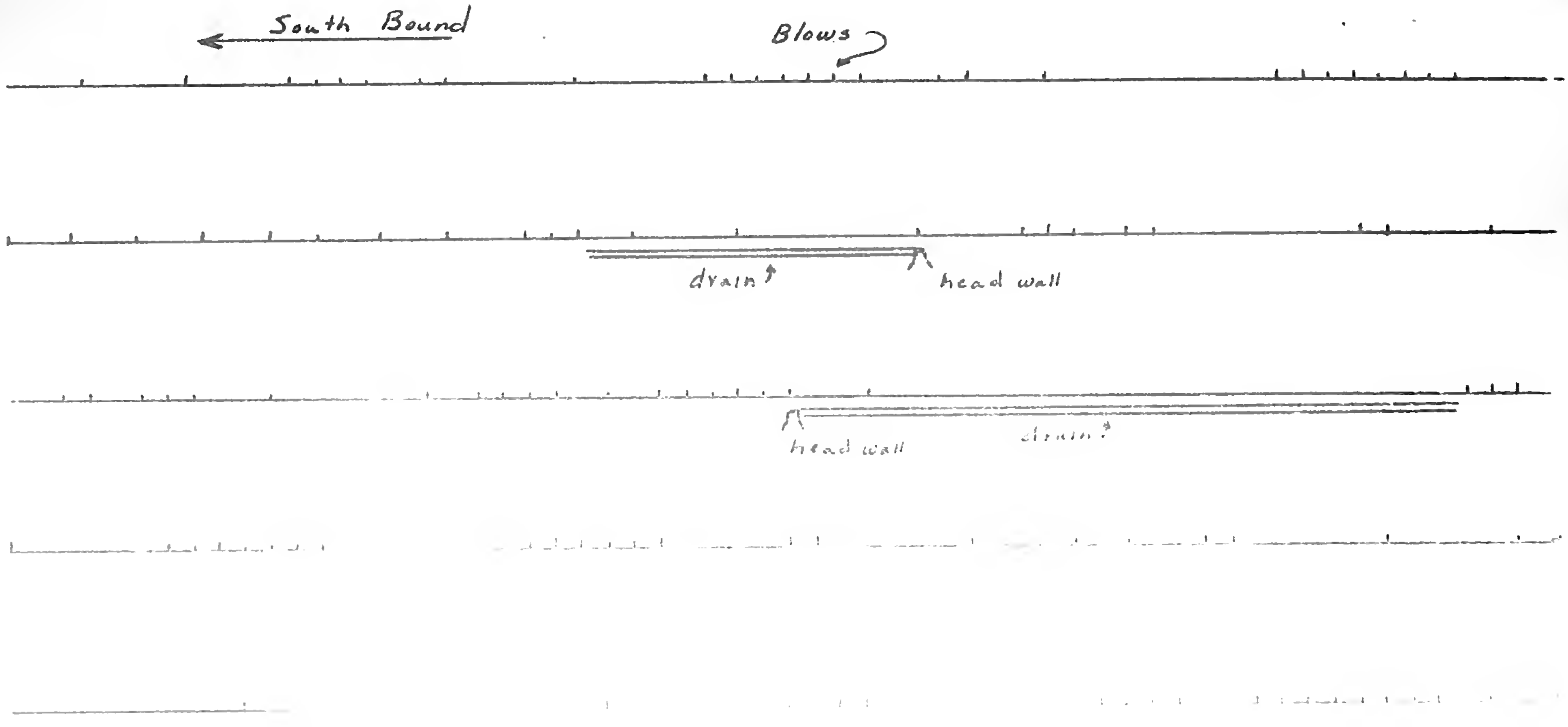


Fig. 19 Effect of Tile Drains, U.S. 52 (Base Through Shoulder Except as Noted)

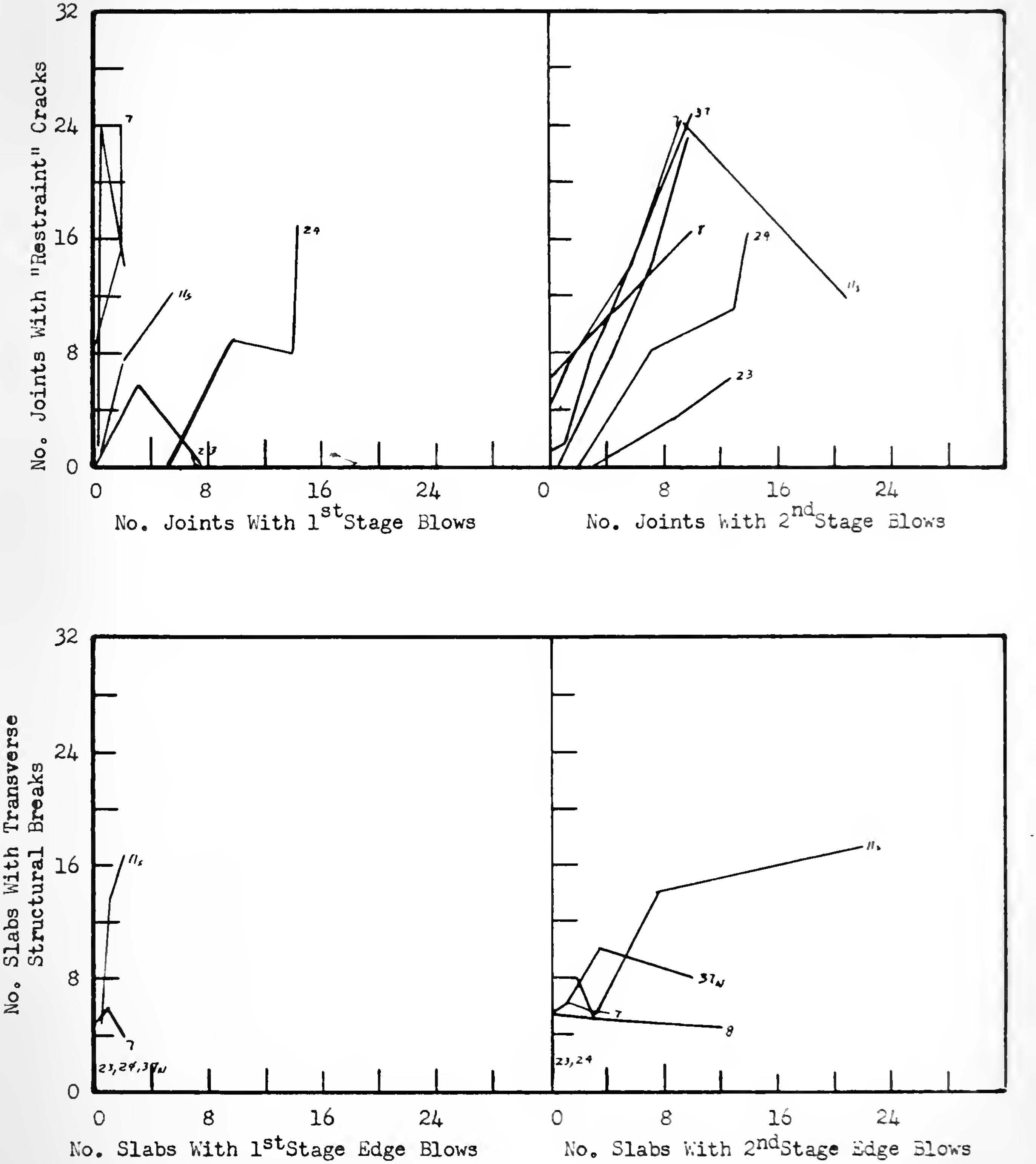


Fig. 20 Variation of Structural Defects With Blowing
(Gravel, Trench Construction, Traffic Lanes)

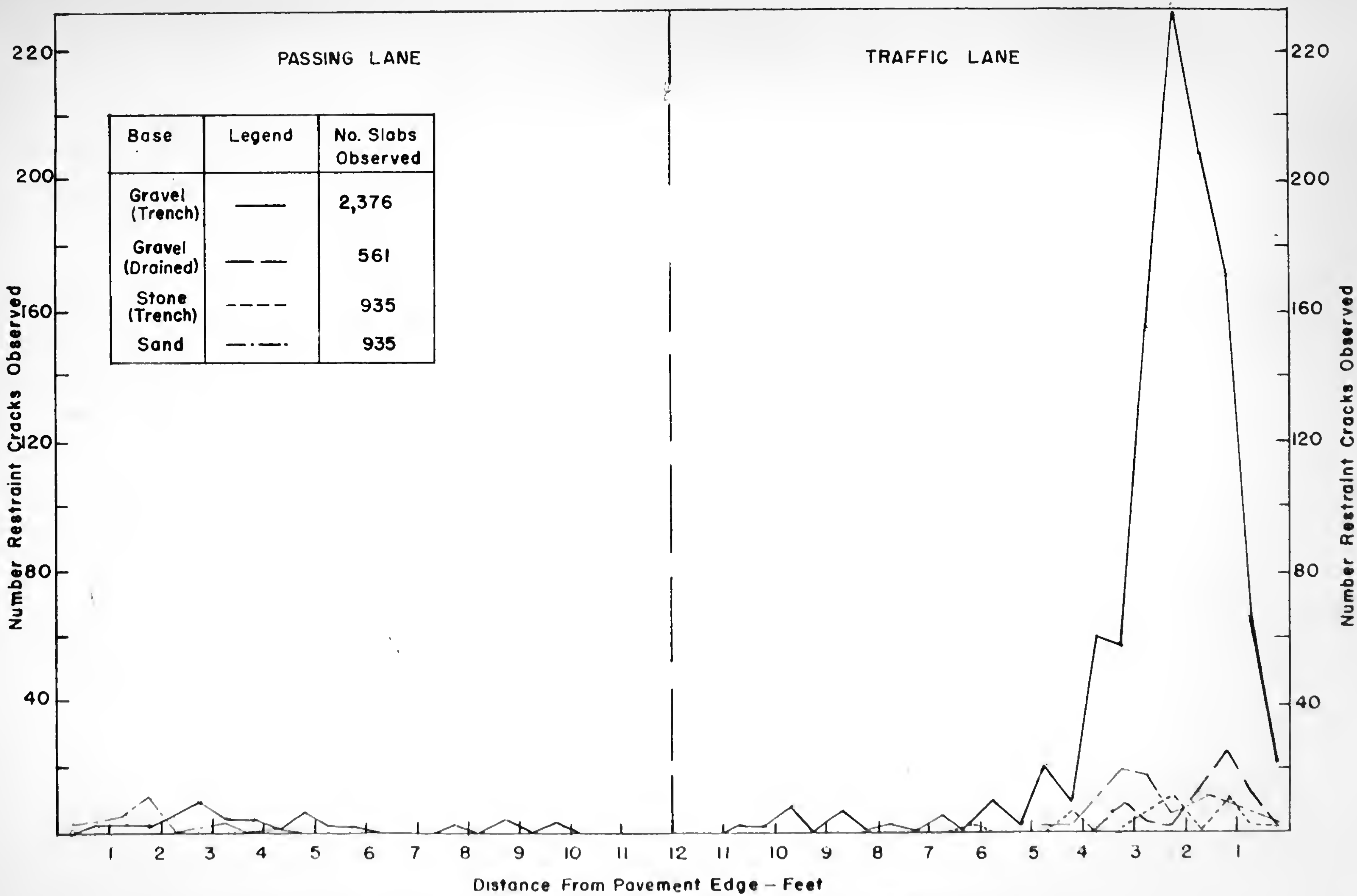


FIG. 21 LATERAL POSITION OF "RESTRAINT" CRACKS

Table 1 Summary of Data

Stretch	Road No.	Load Rep. $x10^{-5}$	Cracks per mile Rest.	Trans cent.	Trans for.	Trans back	Blowing per mile 1st stg joint	1st stg joint	1st stg edge	2nd stg edge
Gravel (trench)										
1	40	50.6	0	30	10	17	0	0	0	0
11	52	27.2	97	91	23	28	15	37	1	3
7	52	26.4	131	92	18	23	6	19	1	1
8	52	25.3	130	91	10	9	3	24	1	6
36	31	——	4	19	7	5	8	8	0	0
45	41	23.3	53	43	10	14	15	0	3	0
33	30	21.69	88	42	9	9	6	40	76	63
50	41	17.4	25	40	2	0	28	0	3	0
6	24	——	15	67	7	8	4	0	0	0
48	41	4.9	14	4	0	1	0	4	1	3
42	157	3.2	1	16	7	3	0	0	0	0
Gravel (through shoulder or drained)										
3	37	12.6	3	33	12	10	0	0	0	0
23	52	10.7	11	7	0	0	19	29	7	10
24	52	10.7	70	10	0	2	68	36	20	2
Sand (trench)										
64	41	41.1	4	143	30	37	6	30	0	0
15	40	38.6	27	75	30	7	0	0	0	0
65	41	30.6	6	83	9	12	0	4	0	0
69	37	6.4	0	3	1	1	2	0	1	0
27	41	4.5	2	3	0	1	7	8	1	0
71	662	2.3	9	1	0	0	0	0	0	0
57	62	1.2	0	0	0	0	0	0	2	0
Stone (trench)										
53	41	20.7	0	60	15	15	39	3	0	0
52	41	20.7	0	52	18	12	43	8	7	0
54	37	10.7	17	13	2	3	8	4	7	2
55	135	3.3	1	0	0	0	0	0	0	0
56	135	1.6	0	0	0	0	0	0	0	0
56	135	0.6	0	1	0	0	0	0	0	0
Stone (through shoulder or drained)										
52	41	10.3	0	3	1	0	0	0	0	0
53	41	10.3	0	0	1	0	0	0	0	0
69	37	3.3	0	6	1	1	3	0	2	0
Gravel (20' slabs)										
1	40	51.9	0	28	0	0	9	2	1	0
30	25	5.4	0	8	2	3	3	1	1	1

TABLE 2

SUMMARY OF PERFORMANCE OF SAND BASES

Road No.	Rep. of All Classes x 365^{-3}	3" or 3"-2½"-1 inch Depth			6"-5" 6"-1 inch Depth Base			7" or 8" Depth Base			9"-6" 3"-6"-9" or 9"-8"-9" Depth Base		
		Pump	1st Stg Blows	2nd Stg Blows	Pump	1st Stg Blows	2nd Stg Blows	Pump	1st Stg Blows	2nd Stg Blows	Pump	1st Stg Blows	2nd Stg Blows
662	0.24	0	0	0									
66	1.30	0	0	0									
37	1.27				0	0	0						
41	2.32										0	7.87	0
41	2.32										0.77	45.53	0
37	2.40										0	1.10	0
37	3.11				0	0.16	0						
41	3.37										0	0	0
41	3.37										0.20	0.61	
31	5.51							0	0	0			
31	5.51							0	0	0			
40	6.86				0	4.43	0						
30	21.60	1.15	14.03	[illegible]									

From Vogelgesang (1)

Table 3. Measured Depths of Bases

(all 40' slabs)

Stretch Section Joint	Road	Base	Drainage	Traffic	Depth Base (inches)					
					No Blows		1st Stage		2nd Stage	
					No Rest.	Rest.	No. Rest.	Rest.	No Rest.	Rest
5-2-12	US 30	G	T	21.96					5	
5-22-18	"	G	T	"		5				
50-3-12	US 41	G	T				5			
33-57-18	US 30	G	T	21.96					4	
33-57-17	"	G	T	"					4	
11-2-20	US 52	G	T	27.2					8	
11-2-25	"	G	T	"		6				
37-1-12	"	G	T	"						5
37-1-18	"	G	T	"		4				
50-3-13	US 41	G	T	17.44			6			
45-7-16	"	G	T	23.32			7			
45-7-17	"	G	T	23.32	6½					
42-14-17	SR 157	G	T	3.20	6					
36-19-12	US 31	G	T	26.23	6					
48-1-14	US 41	G	T	4.97					7	
48-1-25	"	G	T	"	6					
6-42-5	US 24	G	T	16.87	6					
Ave.					6"	5"	6"		5.6"	
24-1-26	US 52	G	S-S	10.67					7½	
24-11-15	"	G	S-S	"			7			
24-11-18	"	G	S-S	"					5	
24-11-32	"	G	S-S	"						7
24-1-31	"	G	S-S	"	7					

Table 3 (continued)

Stretch Section Joint	Road	Base	Drainage	Traffic	Depth Base (inches)					
					No Blows		1st Stage		2nd Stage	
					No Rest.	Rest.	No Rest	Rest.	No Rest.	Rest
23-7-10	US 52	G	S-S	10.67					7	
23-7-7	"	G	S-S	10.67					7	
3-2-4	"	G	S-S	12.59	7					
Ave.					7"				6.6"	
52-11-7	US 41	S	T	20.76					7	
52-11-18	"	S	T	"	6					
53-16-6	"	S	T	"			6			
53-16-18	"	S	T	"	6					
54-26-5	SR 37	S	T	10.72					4	
54-26-10	"	S	T	10.72			(1)			
55-3-8	SR 135	S	T	3.04	4					
56-2-29	"	S	T	1.65	3					
Ave.					5.9"				5.2"	
52-21-3	US 41	S	S-S	10.31	7					
53-6-18	"	S	S-S	10.31	6					
69-16-30	SR 37	S	D	3.29	6½					
57-5-10	SR 62	S	S-S	1.22	8½					
71-15-11	SR 662	SD	T	2.31	6					
15-3-24	US 40	SD	T	38.61	6					
27-2-17	US 41	SD	S-S	4.52			7			
27-2-15	"	SD	S-S	"					7	
67-10-31	SR 37	SD	T		7					
64-8-7	US 41	SD	T	41.07			9			
64-17-20	"	SD	T	"	10					
64-8-30	"	SD	T	"	9					
64-17-14	"	SD	T	"		7				

Table 3 (Continued)

Stretch Section Joint	Road	Base	Drainage	Traffic	Depth Base (inches) No Blows No Rest	No Blows Rest.	1st Stage No Rest.	1st Stage Rest.	2nd Stage No Rest.	2nd Stage Rest
65-8-19	US 41	SD	T	30.64					10	
65-8-4	US 41	SD	T	30.64	12					
65-4-7	"	SD	T	"	10					
65-4-19	"	SD	T	"	9					
Ave.					9.5"		8"		3.5"	

Table 4 Number of Restraint and Transverse Cracks in Cut, Fill and on Grade (Expressed as Per Cent Of No. of Slabs)

	CUT		FILL		ON GRADE	
	TRAFFIC LANE	PASSING LANE	TRAFFIC LANE	PASSING LANE	TRAFFIC LANE	PASSING LANE
RESTRAINT CRACKS	10.6	4.1	8.2	2.1	7.1	0.2
TRANSVERSE CRACKS-CENTER $\frac{1}{3}$	38.6	28.8	25.2	24.5	27.4	20.7
TRANSVERSE CRACKS-FORWRD $\frac{1}{3}$	7.1	2.9	7.3	2.3	3.9	1.2
TRANSVERSE CRACKS-BACKWD $\frac{1}{3}$	7.1	3.9	8.2	3.8	4.5	2.3

SUMMARY OF BLOW HOLE COUNT — US 52
NORTH OF LAFAYETTE, CONSTRUCTED-FALL 1949

STRETCH	SECTION	NO. OF JOINTS OR CRACKS WITH BLOWS AND NO. OF SLABS WITH EDGE BLOWS															
		11-14-50		5-11-54		9-7-54		10-15-54		10-20-54		10-26-54		3-11-55		3-30-55	
		JOINT & CRACK	EDGE	JOINT & CRACK	EDGE	JOINT & CRACK	EDGE	JOINT & CRACK	EDGE	JOINT & CRACK	EDGE	JOINT & CRACK	EDGE	JOINT & CRACK	EDGE	JOINT & CRACK	EDGE
7	3							5	1			1	1				
7	12	9	0	5	2	5	1	16	1	7	1	7	1	1	0	7	2
7	14	18	0			4	1	12	3	6	1	7	2	1	1	4	1
8	24	20	1			7	5	16	5	10	2	9	1				
8	15	4	0	7	3	2	1	15	7	8	4	9	4	7	6	15	10
8	13	4	0	1	0			2	1	1	1	1	0	1	0	1	0
Precipitation-day prior		.00		.00		.00		.72		.00		.00		.48		.00	
" -week prior		1.17		.11		.85		3.74		1.34		.00		(.48)		.00	
" month prior		1.38		3.49		4.58		6.19		6.19		6.19		(1.03)		(1.65)	